# COMBUSTION

FEB 23 1937

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

l. 8, No. 8 FEBRUARY, 1937 25c a copy

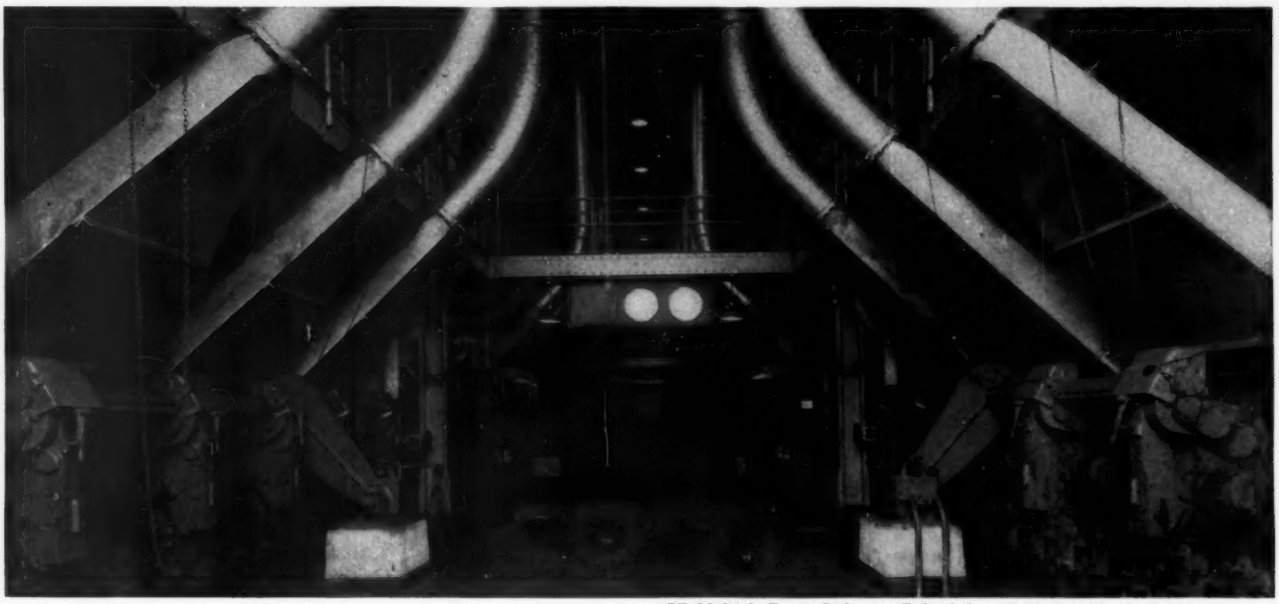
Black Star

## Power and People

## Electric and Water Services Crippled by Flood at Cincinnati

# When you buy

## MULTIPLE RETORT STOKERS



*CE Multiple Retort Stokers at Federal Central Heating Plant, Washington.*

# CHECK these important points

***They will largely determine the return on your investment***

### OPERATING FEATURES

The CE Multiple Retort Stoker, Type MRO, embodies many superior design features, particularly those relating to distribution and control of fuel and air.

Essential adjustments are effected with the greatest facility by means of simple controls conveniently located at the front of the stoker.

The speed of the stoker, the length of stroke of the secondary rams, either individually or in groups, as well as the extent of movement of the grate bars of the overfeed section, are under instant control of the operator. This regulation is accomplished while the stoker is in motion and without the necessity of access to any interior part.

The ease with which all operating adjustments are made encourages the operators to consistently maintain correct fuel bed conditions which naturally results in uniformly efficient performance.

C-E

### COST OF MAINTENANCE

* "The material maintenance on the stokers has been very low, averaging about 2.55 cents per ton over the period of a year."

### CONTINUITY OF SERVICE

* "Upon one occasion a stoker was operated for 8 months without any shutdown for repairs."

### EFFICIENCY

* "Average overall boiler operating efficiency is about 80 per cent."

(Note: boiler and furnace efficiency only—no economizers or air heaters installed. Averaged results of 5 official acceptance tests show efficiency of 83.48 per cent.)

* QUOTATIONS from a recent article by J. F. Barkley, Supervising Engineer, Fuel Economy Service, U. S. Bureau of Mines, and Chas. A. Peters, Jr., Ass't Director, National Park Service, relative to the performance of 6 CE Multiple Retort Stokers which have been in operation since January 1934 at the Federal Central Heating Plant, Washington, D. C. These stokers fire CE Sectional Header Boilers. A reprint of the article is available upon request.

## COMBUSTION ENGINEERING COMPANY, INC.

**200 Madison Ave., New York, N. Y.** ***Canadian Associates*****—Combustion Engineering Corp., Ltd., Montreal**

A-336a

# COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

VOLUME EIGHT NUMBER EIGHT

# CONTENTS

## FOR FEBRUARY 1937

### FEATURE ARTICLES

| | | |
|---|---|---|
| Power and People | *by John C. Parker* | 22 |
| Electric and Water Services Crippled by Flood at Cincinnati | | 25 |
| Prevention of Spontaneous Heating of Large Coal Piles | *by M. K. Drewry* | 28 |
| Some Factors Influencing Design of Pulverized-Coal-Fired Steam Generating Units | *by Otto de Lorenzi* | 33 |
| Flue Gas Separators | *by K. Heinrich* | 36 |
| Dust-Prevention Treatment of Solid Fuels | *by L. D. Schmidt* | 39 |

### EDITORIALS

Plant Data ... 21
Revised Boiler-Tube Thicknesses ... 21
Behind the Scenes ... 21

### DEPARTMENTS

Steam Engineering Abroad ... 43
Review of New Books ... 47
Equipment Sales ... 48
New Equipment—Multi-Pointer Gage, Portable $CO_2$ Indicator, Gage Valves for High Pressures, Remote-Reading Water Gage, Automatic Orsat ... 49
New Catalogs and Bulletins ... 50
Advertisers in This Issue ... 52

H. STUART ACHESON, *Advertising Manager*

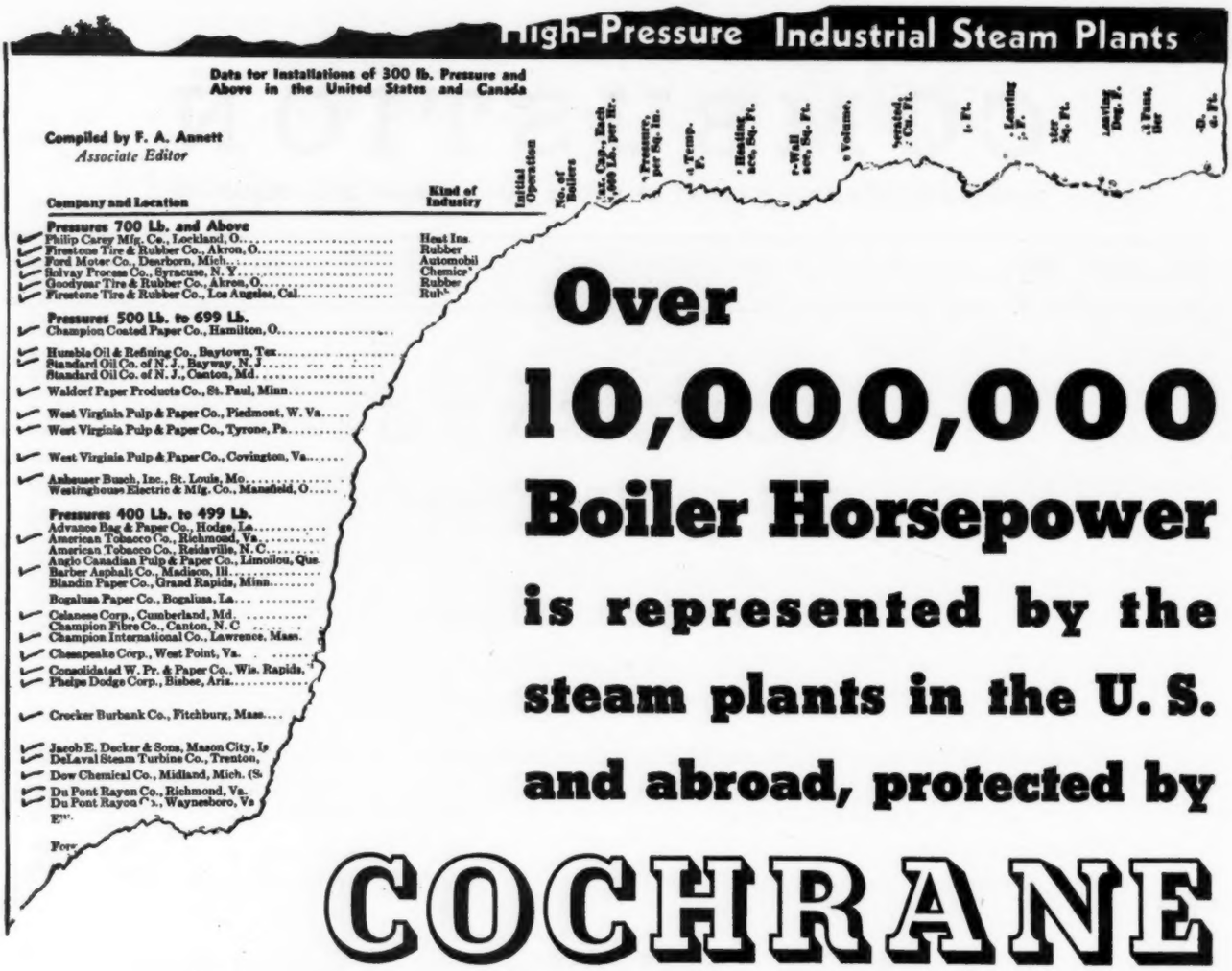
ALFRED D. BLAKE, *Editor*

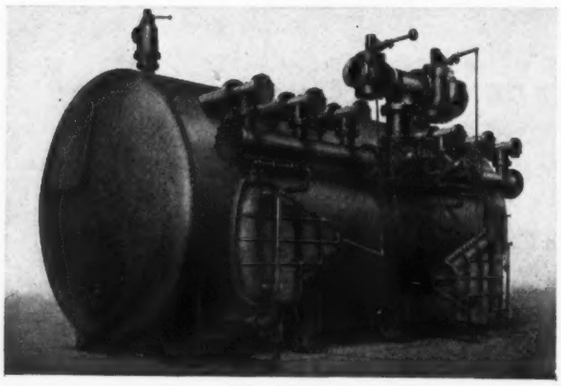
THOMAS E. HANLEY, *Circulation Manager*

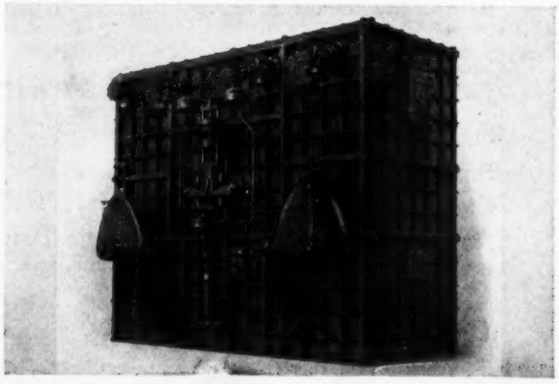
Combustion is published monthly by Combustion Publishing Company, Inc., a subsidiary of Combustion Engineering Company, Inc., 200 Madison Avenue, New York. Frederick A. Schaff, President; Charles McDonough, Vice-President; H. H. Berry, Treasurer; G. W. Grove, Secretary. It is sent gratis to consulting and designing engineers and those in charge of steam plants from 500 rated boiler horsepower up. To others the subscription rate, including postage, is $2 in the United States, $2.50 in Canada and Great Britain and $3 in other countries. Single copies: 25 cents. Copyright, 1937, by Combustion Publishing Company, Inc. Printed in U. S. A. Publication office, 200 Madison Avenue, New York. Issued the middle of the month of publication.

Member, Controlled Circulation Audit, Inc.

CCA


High-Pressure Industrial Steam Plants
Data for Installations of 300 lb. Pressure and Above in the United States and Canada
Compiled by F. A. Annett
Associate Editor
Company and Location
Kind of Industry
Initial Operation
No. of Boilers
Pressures 700 Lb. and Above
Philip Carey Mfg. Co., Lockland, O.
Firestone Tire & Rubber Co., Akron, O.
Ford Motor Co., Dearborn, Mich.
Solvay Process Co., Syracuse, N. Y.
Goodyear Tire & Rubber Co., Akron, O.
Firestone Tire & Rubber Co., Los Angeles, Cal.
Pressures 500 Lb. to 699 Lb.
Champion Coated Paper Co., Hamilton, O.
Humble Oil & Refining Co., Baytown, Tex.
Standard Oil Co. of N. J., Bayway, N. J.
Standard Oil Co. of N. J., Canton, Md.
Waldorf Paper Products Co., St. Paul, Minn.
West Virginia Pulp & Paper Co., Piedmont, W. Va.
West Virginia Pulp & Paper Co., Tyrone, Pa.
West Virginia Pulp & Paper Co., Covington, Va.
Anheuser Busch, Inc., St. Louis, Mo.
Westinghouse Electric & Mfg. Co., Mansfield, O.
Pressures 400 Lb. to 499 Lb.
Advance Bag & Paper Co., Hodge, La.
American Tobacco Co., Richmond, Va.
American Tobacco Co., Reidsville, N. C.
Anglo Canadian Pulp & Paper Co., Linoilou, Que.
Barber Asphalt Co., Madison, Ill.
Blandin Paper Co., Grand Rapids, Minn.
Bogalusa Paper Co., Bogalusa, La.
Celanese Corp., Cumberland, Md.
Champion Fibre Co., Canton, N. C.
Champion International Co., Lawrence, Mass.
Chesapeake Corp., West Point, Va.
Consolidated W. Pr. & Paper Co., Wis. Rapids, Wis.
Phelps Dodge Corp., Bisbee, Ariz.
Crocker Burbank Co., Fitchburg, Mass.
Jacob E. Decker & Sons, Mason City, Ia.
DeLaval Steam Turbine Co., Trenton, N. J.
Dow Chemical Co., Midland, Mich. (S.
Du Pont Rayon Co., Richmond, Va.
Du Pont Rayon Co., Waynesboro, Va.
Over
10,000,000
Boiler Horsepower
is represented by the
steam plants in the U. S.
and abroad, protected by
COCHRANE
Engineering & Equipment





**COCHRANE CORPORATION - 3109 North 17th St. - Philadelphia, Pa.**

# COCHRANE

WATER SOFTENERS • DEAERATING HEATERS • FILTERS • BLOW-DOWN EQUIPMENT • VALVES • FLOW METERS

# EDITORIAL

## Revised Boiler-Tube Thicknesses

Compared with German practice, the prescribed thickness for tubes of water-tube boilers in this country has, in the opinion of many, long been greater than necessary. Despite advances in metallurgy and methods of manufacture, the employment of smaller tubes with increased pressures, and greatly increased radiant heat absorption, the thickness has remained unchanged since the A.S.M.E. Boiler Code was first issued over twenty years ago.

Therefore, in order to bring the prescribed thickness in line with the requirements of present conditions the A.S.M.E. Boiler Code Committee has lately drafted a proposed revision of this section which was printed for comment in the January issue of *Mechanical Engineering*.

The revision does not go as far as the German rules in reducing tube thickness but makes a substantial reduction especially in the smaller diameter tubes in the pressure range above four hundred pounds. For low pressures, where tubes of larger diameter are employed, the thickness remains as before. The new values take into consideration the reduction in temperature stresses due to furnace radiation as afforded by the reduced tube thickness; also tightness and stresses incurred through rolling into the header or drum.

German practice favors the use of alloy steels for tubes and the employment of ferrules for increasing the adhesion of rolled-in tubes or the welding of soft steel ends to the alloy tubes to facilitate rolling. Neither of these have met with favor in this country. While the somewhat greater tensile strength of the alloy steels permits further reduction of tube thickness under the German rules, such steels have certain characteristics that, in the opinion of many American engineers, do not make them most desirable for boiler tubes. Therefore, the proposed revision of the A.S.M.E. Code may be regarded as a distinct advance, embodying the best informed opinions, and taking into consideration those factors peculiar to American practice.

## Plant Data

Compilations of plant data, both design and operating, are always welcomed by power engineers. They are both interesting and, to a limited extent, informative. However, while such data, viewed collectively, may be taken as indicative of trends, they are likely to be quite misleading as a basis for design factors, unless known to be comparable in all essential respects with the case under consideration. This is especially true at present when practice is advancing so rapidly and when many diverse conditions have to be met by "tailored" designs to suit the individual plant. It is important, therefore, that data be complete so that intelligent comparison may be possible.

As to design ratios, a case in point is the heat release per cubic foot of furnace volume. This will be found to vary considerably for different installations and for different methods of firing. There has been a tendency to place undue emphasis on this ratio, whereas it is not the principal factor in determining furnace volume, inasmuch as it does not take into account the rate of heat absorption by the furnace walls.

Again, the distribution of heat absorbing surface in the modern steam generating unit shows the trend of present practice, especially the smaller part played by the boiler heating surface; but the proportionate distribution varies to such an extent for individual installations that the values have little or no specific application.

Many other ratios are in this category.

The same reasoning applies to performance. Unless the fuel, steam conditions, load characteristics and general refinements of plant design are strictly comparable and carefully weighed, the excellent economic efficiency of one plant may be overshadowed by the higher thermal efficiency of another.

While maintenance narrows down to individual equipment, here also fuel and operating conditions, as well as the influence of complementary equipment, play an important part.

In view of these considerations, judgment should always be withheld until all the supporting data are available, including operating characteristics and experience which, in the final analysis, determine the fitness of a design.

## Behind the Scenes

In this issue appears a first-hand account, from our local correspondent, of how the flood affected electric service and water supply in Cincinnati. Similar accounts might have been written of numerous other cities in Kentucky, Indiana, West Virginia and southern Illinois, where comparable conditions existed. They serve to impress one with the dependence which urban life places on such public utility services, but they do not reveal the many intimate stories of heroic efforts to maintain and restore these vital services. These have involved personal hazard, long hours without rest and taxed the resourcefulness of engineers and operating personnel.

With subsiding waters there was no let-up in the work of the engineers. Electrical equipment of all kinds required drying out and testing, often with improvised means, and there was an urgent appeal from many of the flooded areas for electrical engineers to assist in this work. The service men of equipment manufacturers have responded and assumed their share of these tasks.

Many interesting stories of what was accomplished under these trying conditions might be told; but at the time these men were too busy, and after the emergency has passed, they will be disposed, with characteristic reticence, to regard the experiences as just a part of their work. It is unfortunate that the more spectacular and tragic aspects of the flood have overshadowed the important rôle of these men.

# POWER and PEOPLE

By JOHN C. PARKER, Vice President
Consolidated Edison Company of New York, Inc.

**In these excerpts from an address before the A.I.E.E., January 27, on the occasion of the Edison Medal Presentation to Dr. Alex Dow, Mr. Parker endeavors to assess the true place of power in social progress, as one of many factors, and warns against an exaggerated or over-enthusiastic conception of its ability to achieve certain ends, particularly with reference to rural electrification.**

PROBABLY there is no calling more definitely social in its character than is that of the engineer. The engineer does not live a life of isolation but on the contrary works with and through other men. His work, whether it be in research, design, construction, production or commercial distribution, involves understanding of, an adjustment to and cooperation with other men. He has then a high reality of contact within a closely articulated social unit. In this, his work is definitely more social than that of the physician or of the lawyer, each of whom, in a large degree, works as an individual. In that very fact, however, the engineer has at once a satisfaction and a limitation of his social contacts. With other men, largely of identical or at least of closely related interests and limitations, he finds satisfaction for his desires for human contact and such satisfaction easily enough so preoccupies his time that he can easily fail of social understanding of the people whom his profession serves or of the social significances of his own works.

The physician or the lawyer, on the other hand, carrying on an individual practice even with people in their less normal temper or physical state, does have of necessity a vividness and reality of contact with people other than his co-professors, and properly to do his work must have the imagination broadly to interpret their lives, their needs and the significance of his professional efforts in their behalf. These individual service professions do come closer to the people served than engineering.

In consequence of engineering remoteness, we perhaps become obsessed with the technical beauties and interests of our work and with the human problem of co-ordination with our fellows in creation and miss some perspective of how our works touch on the larger interests of society. Not infrequently it seems we have missed entirely the large significances of engineering and perhaps as frequently, in the fashion so common among self-deprecatory people, we have put up a certain defensive insistence on importances which simply do not exist.

If at both extremes the world has taken us at our own depreciated valuation, there can be little complaint on our part, nor can there be any great surprise if the less ponderable and less obvious values in us and in our works are not spontaneously accepted. Of course, it hurts our finer professional sense if people think of us as mere technicians of unimportant arts, whether the niceties of sound engineering analysis are appraised merely as necessary contributions to a socially unimportant technique, or, as might be inferred from lay references in the news columns and in the advertising space, the engineer is esteemed as only a slightly sublimated form of mechanical handyman.

On the other hand, when laymen, editorial writers and public officials agree with us in adulation of our works and hail engineering achievement as the be-all and the end-all of social progress, it is easy for us smugly to agree with what is at once too narrow a conception of the value of our work and too great an emphasis on its place in a world of human beings. When such a philosophy becomes characteristic of a nation or of a period, we may well be in desperate danger. There is not exaggeration in the belief that a disproportionate acclaim is given to mere mechanical achievement.

### *Attributes of the Engineer*

The engineer, who is an engineer, approaches his work without bias and with a mind freely open to conviction. He cannot be a special advocate and remain in any professional sense an engineer. Whatever may be the limits of his vision, he does at least possess a fine objectivity in his imagination. For him no sentimentality or wishful thinking will conjure up visions different from the world of things as they are. His creative thinking is the finer ability to project the observed facts of today into principles and rules of conduct and a clear picture of possibilities that are certainties because their origins are actual.

Because of his freedom from bias and the objectivity of his thinking, he must of necessity be possessed of integrity, and because he is intellectually honest and open-minded he is tolerant of judgments that do not conform with his own, while courageous and firm when he gets out of the field of opinion and into that of fact.

If as a profession we can gain acceptance by the world of the personal qualities of the engineer as freely as it has been willing to accept his works, society's debt to us will be enormously greater. The works as well as the character of the engineer give him a right to claim a great place in the esteem of mankind, not for the things themselves but for these things in their relation to civilized living and thinking. There is a profound and important difference here and one which in practical ef-

fect needs the most painstaking care to avoid damaging, if not fatal, error.

There is a general public interest in the problems of power production and distribution that is out of proportion to any significance even so important an art has in the affairs of men. This would be puzzling if it were only a recent phenomenon. It is not the less disturbing because of the fact that it has been developed over a period of years by an ill-considered but perfectly honest enthusiasm which has mistaken simultaneity of occurrence for a relation of cause and effect.

### *Power in Industry Overemphasized*

When in the middle and late 20's the rest of the world was suffering the economic aftermaths of war and we in this country were riding on the full tide of what we believed to be prosperity, we explained to ourselves that we had so many horsepower back of the elbow of every American working man. The Daily Mail sent an English commission to discover that mechanically developed power was the great secret of American prosperity; the Soviet Union initiated its series of five-year plans with an emulation of the great American electrical industry; while Fascist Italy sought to develop the backbone of the peninsula through a superpower system. I have no quarrel with these things, but I had then and have today a profound disagreement with a wrong emphasis.

The power engineers of this country had done, as the engineers have done in practically every field of American endeavor, a glorious job and they continue to do so. We have produced and distributed a superlative quality of service at extraordinarily low prices. It has been made available to the largest feasible percentage of the population and is used in a degree almost unrivalled throughout the world. Yet this much vaunted power use did not suffice to keep us from plunging headlong and with characteristic American vigor into the world depression. There is no reasonable basis for believing that power development on an even greater scale in this country is going to pull us into the prosperity which the secret of American well-being a dozen years ago wasn't able to preserve for us. Claiming all the territory in sight at that time was a result of pretty superficial thinking. Power engineers today would be foolish if they accepted the responsibility implied in the theory that dynamic development is a thing precedent to social or economic uplift. Acceptance of any such idea will simply find the power people again discredited.

Let us see what the actual fact is in regard to the place of power development in the American industrial picture of the pre-depression days. There was more power at the command of the worker in industry than existed anywhere else in the world. It is so rudimentary as to be almost trite to say that the factory worker didn't take $x$ kilowatts into his hands and apply them directly to a bunch of steel ingots and have a freight car emerge from the process. Not only that, but American industry didn't set out with the idea of trying to apply power to industrial production and thereafter discover the means for utilizing power. Ingenuity, energy, the courage of conviction produced the machine tool, the turret-lathe, the automatic screw machine, punch presses and drop hammers. These called for power and for power in ever increasing quantities. Without an ample supply of dependable power at modest prices we should have had carefully to restrict the use of power in manufacture and the hand processes would have persisted here as they have elsewhere.

The power industry saw a commercial opportunity and observed a social responsibility. Its place in the picture is sufficiently great in that it did supply that which was necessary to the operation of the machine tool.

Neither power nor the machine tool without the other could have established the American methods in industry, nor could the two of them together have done very much without the development of elemental metals and of alloys and plastics which should lend themselves to the processes of quantity and production. These again would have been of little use had it not been for the development of design directed quite as much to the working of modern materials through the power driven machine tool as to the functioning of the product after it was made. But neither design for production, nor modern materials, nor machine tools, nor the power to drive them, or any of them in combination, would have been of the slightest use without one of the greatest contributions that America has made to industrial progress. That contribution may be described in any one of its aspects as the use of tolerance limits, interchangeability of parts, standardization and the use of limit gages.

When all of this is said and done we haven't yet quite approached the full story of the place of power in the business of satisfying the needs of the people. Engineers well understand that the process of industrial production is a function of quantity. Below a rather large minimum an enterprise cannot develop the methods of interchangeability which make the machine tool tolerable or which bring power into the service of the workman. Enterprise and courage and a reasonable assurance of success are necessary as inducements to the people who risk their savings in enterprise which may become obsolete on a whimsical turn of fashion or impotent through a major economic disturbance. This is the part of the entrepreneur who, in a very real sense and working outside the fields of power development, has been necessary to the development of the industrial uses of power in this country.

### *Distribution an Important Factor*

All of these elements put together might have accomplished nothing had it not been for the achievements in distribution which have brought the end results of industry to the final user.

I am not permitting my enthusiasm to enlarge the importance of the non-engineer in this whole sequence of development. I know perfectly well that salesmen and capitalists didn't in the first instance plan all that they have produced any more than the power engineer, when he developed his induction motor, had any idea of applying it to the rolls of a steel mill. I am simply saying that these people, like ourselves, recognized facts as they came along and had imagination to build from them a little at a time until from gradual progress there developed a philosophy of commercial existence. Indeed had they tried to devise an economic or industrial system out of their own imaginings they would probably have come off very badly indeed.

The machine tool itself was a product of necessity. It probably never would have come into at all substantial use had it not been that the cost of supporting the typical American workman made necessary some means of tremendously increasing his productivity.

Note that every one of these elements has been essential to modern industrial life; even more than that, they have been essential to modern non-industrial living. Our enthusiasm for one of these elements in which we may happen to be particularly interested—let us say power—should not run away with our sense of proportion. On the contrary, it seems that our pride in our own service becomes greater if we have an adequate picture of where it fits in as an essential and considerable element of something enormously bigger than itself.

We need not be at all deprecatory of the importance of our power developments as service to the home or to the farm merely because we may be realistic in our apprehension of the fact that many other things enter into life. It is understandable, though not by virtue of that at all defensible, that the specialist should develop an unrestrained enthusiasm for his particular field of human endeavor and that his extreme loyalty might communicate his zeal to others. What is not perhaps quite so clear is that economic, social and political injuries may result from these widespread and exaggerated enthusiasms. Not alone as a matter of humane consideration, but in self defense against the reactions of disappointed hope, we must be at pains not to arouse desires that we cannot gratify or which, gratified, will be found not all that the body or the soul of man craves.

Energy available as a contribution to carrying on the amenities of domestic life is, beyond question, almost, but not quite, indispensable and a long, long way from being all-sufficient. Let me qualify this a bit. Energy in some form or other is, of course, necessary to human existence. For all of the necessities of life there are substitutes for these forms of energy with which we, as engineers, are most concerned, and in some applications these other and more ancient forms come very close to the excellences that we can offer.

It is perhaps reasonable to suspect that a good deal of the current abnormal interest of the people in power problems may be due to their persuasion that this, that or the other, overly exploited device is essential to civilized living if not a sure cure for all of the difficulties thereof, instead of being, as in many cases it is, a most remarkably adept contribution thereto. A profound conviction of the value of extending to the farm the power use which has been so common in industry may run away with itself.

### *Rural Electrification*

Over twenty-five years ago, as Chairman of the Committee on Electricity on the Farm of the Association of the Industry with which I was identified, I had occasion to know those early efforts at a broadened use for power. My own company in the rich farm country of western New York discovered at once the values, the difficulties and the limitations of farm supply from contiguous distribution circuits. From such a realistic background, I have observed with much satisfaction the various well-planned efforts which, in this country of vast sub-economic areas, have saturated every section whose intrinsic economy at all approaches the productivity or the population density of western Europe.

On the other hand, I note a marked parallel between power use and the human relations. Farm use is least in those states where farm tenancy is common and progressively greater until we reach an extraordinary saturation in the low, rock-ribbed, stubborn but user-owned farm country of New Hampshire.

This and similar human factors make it important that we note certain limitations in this as in other desirable fields of power development.

In the first instance, the farm is not a quantity production factory. Its functions are biologic and not mechanical, and the conditions are not repetitive nor even precisely cyclic. The economic contribution which power makes in industry cannot reasonably be expected to have any parallel in farming. The economic welfare of the rural regions is much more intimately concerned with soil quality and selection of strains and with plant and animal pathology and with market problems and transportation than with the application of mechanical power. Success of our endeavors in industry does not necessarily indicate that we can contribute equally richly to agriculture.

Rural electricity, of course, can contribute markedly to ameliorating the conditions of rural life, but here, as in claiming too much for the economic values of farm electrification, we must be reasonably careful that we do not arouse hopes that can only result in frustration. Strangely enough it seems not to be popularly recognized, nor even to be realized by those better informed technically, that the refinement of running water in the home is not, excepting in the least degree, related to electric wires along the highway. Yet a thumbing of the pages of any mail order catalog will bring pretty vivid conviction of the fact that pumps, piping and fixtures not only are the essence of that particular evidence of civilization but that they are somewhat easily to be had. Until the essentials of sound sanitation are sought by the rural population one wonders at times about the value of the electric circuits.

The most distressingly backward of our rural communities do not in all conscience need electric power, either economically or as adjuncts to living, one-tenth as much as they need many other things closely at hand but still frightfully difficult of attainment within a farm income restricted so narrowly as to make impossible many of the mere decencies of life. I even have a suspicion that when a good job has been done in the way of aiding and advising in an improved agricultural technique and when the intimacy of human understanding offered by education and the means of communication and transportation has itself ameliorated farm living, as a result of the economic and social improvements, power lines will almost automatically have become extended to every part of the farm community intrinsically capable of supporting the purchase of the devices necessary to the utilization of power.

Failing of these things, there is grave danger that when experience shows electric service to be, as it must for a long time continue to be, unattainable in vast stretches of this country, or when the farmer along the electric right-of-way finds his economic lot and his social outlook not essentially different than formerly, disappointed hopes will vent themselves at the expense of those who encouraged them.

What I have been trying to say is that important as is power as an adjunct to factory, farm and home, it, in and of itself, will not revolutionize life. We are, in our most profound relations, biologic creatures and all the conscious mechanical and technical efforts in the world are small factors in determining our essential well-being.

# Electric and Water Services

*Dan Henry, Hugh Watson Field, Sharonville, O.*

**Columbia Station at height of the flood as viewed from airplane**

# Crippled by Flood at Cincinnati

**A first-hand account of the crippling of public services in Cincinnati during the recent flood and of measures taken to alleviate the situation. The crest of the flood exceeded by 9 ft all previous high water records and inundated the two steam stations supplying electric service, as well as the two waterworks pumping stations. Power received over tie-lines from outside sources sufficed to meet only one-seventh of the normal demand and this was allocated to certain essential services. The very limited amount of water in the hilltop reservoirs was turned on only for an hour daily and some sections of the city were without water. The natural gas supply, however, was undisturbed, except in a few outlying sections.**

AN urban population of about 750,000 suddenly deprived of most of its water, light, power and transportation facilities presents one aspect of the serious situation that prevailed at Cincinnati during the period of high flood conditions.

The city is served with electricity by two steam generating stations of the Cincinnati Gas & Electric Company. These are the West End Station in the downtown section of the city, constructed in 1916, and the Columbia Station, about twelve miles below the city, built in 1925. When these plants were designed the records of the U. S. Weather Bureau, covering a hundred years, were consulted. These showed that the maximum height to which the Ohio River had risen during this period was 71 ft in 1884. Therefore, both stations were designed on this basis.

On January 17, when the Weather Bureau warned of an impending flood of unusual magnitude, the Cincinnati Gas & Electric Company hurriedly constructed a three-foot brick wall around the condenser pits, extending all the way to the main turbine-room floor. The men who laid the brick worked waist-deep in water. While the

wall was ample in height, the adverse conditions under which it was constructed rendered it not watertight, and water leaking through this wall into the condenser pits eventually caused the plant to shut down. This occurred early on the morning of January 25 when the river reached a level of 78.3 ft.

The Columbia Station had been forced to shut down the preceding afternoon when the river had attained a height of 68.9 ft. The crest of the flood was reached on January 26 and remained at the level of approximately 80 ft for two or three days.

By January 30 the river had receded to 75 ft and, by heroic efforts, the operators at West End Station were able to put in service one of the four 36,000-kw units. The second unit was placed in operation on February 1, the third on February 3 and the fourth the following day.

Inasmuch as the normal peak load of the system is over 200,000 kw and the capacity of the West End Station is only 144,000 kw, it became necessary, even after this station was restored to service, to ration the use of electricity until conditions permitted restoration of service from the Columbia Station. One of the 65,000-kw turbine-generators in the latter station was restored to service during the afternoon of February 6 and the second unit on the evening of February 9.

With the generators operating in both stations the company was able to supply some excess power to Louisville, Ky., which by that time was in serious straits.

During the period that both stations were out of service, the power company was able to obtain about 35,000 kw capacity through tie-in lines with Dayton, and an additional 15,000 kw from Indianapolis. This, however, constituted only about one-seventh the normal requirements and it was allotted to the most essential services, including hospitals, newspapers, the telephone company, etc. Street cars, traffic lights and residential supply were entirely cut off.

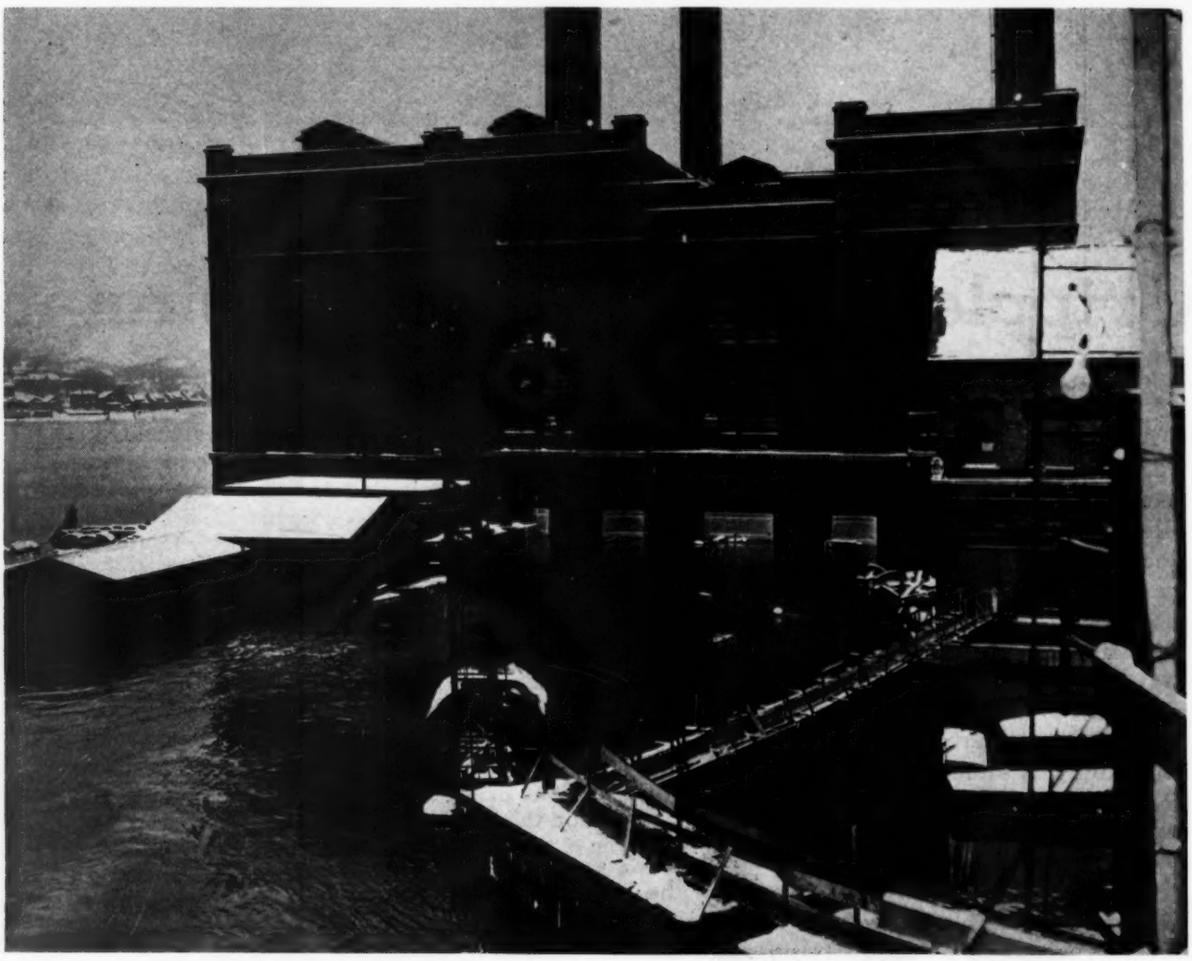
The Cincinnati Gas & Electric Company has already formulated plans to prevent future shut-downs from floods even of such magnitude as the one just passed through.

### *Natural Gas Supply Mostly Intact*

Fortunately, Cincinnati is supplied with natural gas from the West Virginia fields. By undaunted courage on the part of individual workers and through splendid company organization, gas service was maintained throughout the emergency except in three suburban sections where the flood waters broke the feeder mains.

### *Water Supply Crippled*

The water system for Cincinnati is supplied from the Ohio River by two pumping stations. One of these, the River Station, is located at California, O., a few miles up the river, and the other, the Main Pumping Station, is on



**West End Power Station of the Cincinnati Gas & Electric Company**

**Main Pumping Station, Eastern Ave., Cincinnati**

Eastern Avenue. These were built for a maximum river height of 72 ft.

The River Pumping Station at California takes the water from the Ohio River and pumps it to large reservoirs where it is filtered and treated. From these reservoirs the water goes to the Main Pumping Station, which delivers it to seven or eight other reservoirs located on the hilltops from which it is supplied to all sections of the city. Therefore, when both pumping stations were put out of service on the evening of January 24, only a relatively small amount of water in the hilltop reservoirs was available for an indeterminate period. In order to conserve this limited supply, the city water department opened the valves from these reservoirs for one hour each day so as to divide up this supply for an anticipated period of sixteen days. However, with the piping system full of air the pressure produced by gravity was so small that only the downtown business section was able to get any water. This small supply was allotted to essential services and not to offices or stores.

It was not possible to again start the Main Pumping Station until the morning of February 3 and this supplied only the Eastern Section of the city, and not until the following day was the water supply reestablished to the western end of the city.

Great credit is due the personnel of the Cincinnati Gas & Electric Company for the handling of the power situation during the emergency, and also to C. A. Dykstra, City Manager of Cincinnati, for the handling of the water situation. At the beginning of the flood the City Council appointed a Disaster Committee to handle each phase of the situation with Mr. Dykstra in supreme command.

The accompanying illustrations show the West End Station and the Columbia Station during the peak of the flood; also the Main, or East End, Pumping Station.

---

## Refinery Fuels

The consumption of oil as a refinery fuel is declining, according to a survey recently reported by the U. S. Bureau of Mines. This is attributed to increased prices of fuel oil and gasoline which make fuel oil more valuable as an industrial fuel and for cracking. Offsetting this decline has been an increase in the burning of acid sludge and still gas.

Figures for 1935, which are the latest available, showed that of the total heat units generated at refineries, oil accounted for 31.8 per cent, acid sludge 3.9, coal 5.3 and natural gas 14.2. Percentages are not given for still gas and petroleum coke. The amount of electricity purchased by refineries amounted to 1,071,841,000 kwhr.

# Prevention of Spontaneous Heating of Large Coal Piles

By M. K. DREWRY
The Milwaukee Electric Railway and Light Co

**Packing, asphalting and covering with one-foot layer of fine air-tight coal are individually involved in several experiences with 50-ft high piles of 40,000 to 120,000 tons treated in this article. Fine coal covering of piles has proved effective and practical, and has been adopted by The Milwaukee Electric Railway and Light Company for storage of coal at its new Port Washington plant.**

## Initial Project (Asphalting)

THREE-YEAR storage of a 50-ft high pile containing 120,000 tons of 2.83 per cent sulphur, freshly mined, dusty run-of-mine coal, located in a position exposed to high winds and unfortunately handicapped by all factors inducing spontaneous heating, offered a problem that impelled thorough study of this subject. Continuance of the economic depression and resultant postponement of construction of the Port Washington power plant, for which the coal was purchased, necessitated provision for three years' storage.

Though the pile was carefully built and packed according to best known methods, it heated within a few months to the point that something effective had to be done. Fig. 1 shows how the temperatures increased. No room was available for exercising the usual practice of cooling by rehandling, and there was little prospect of using any of the coal for a year or two.

Complete reliance was placed upon the principle that exclusion of air would positively prevent heating. How to exclude air over the enormous surfaces involved was not easily visualized.

An asphalt coating was finally decided upon as the most practical, and the top of the pile was levelled and asphalted in October, two months after storage and when the average pile temperature had reached 120 F. Only the top was covered, based on the assumption that stack-effect of the high pile was most responsible for the heating.

### *Asphalting*

Heating continued after asphalting the top. By December, temperatures at one point suddenly approached 800 F, proving that burning was occurring. Previous temperature rises after periods of high winds proved that the sides should be asphalted if any benefit was to be derived from such fireproofing. Accordingly, the difficult task of applying asphalt to the 35-deg slopes of a 50-ft high pile in winter with sub-zero temperatures and occasional snowfall was necessary. Ordinarily, asphalt is applied to roads only in summer. Experience of another division of the Company in applying asphalt was used to advantage. A three-ton asphalt-spreader truck was engaged and equipped for handling by the

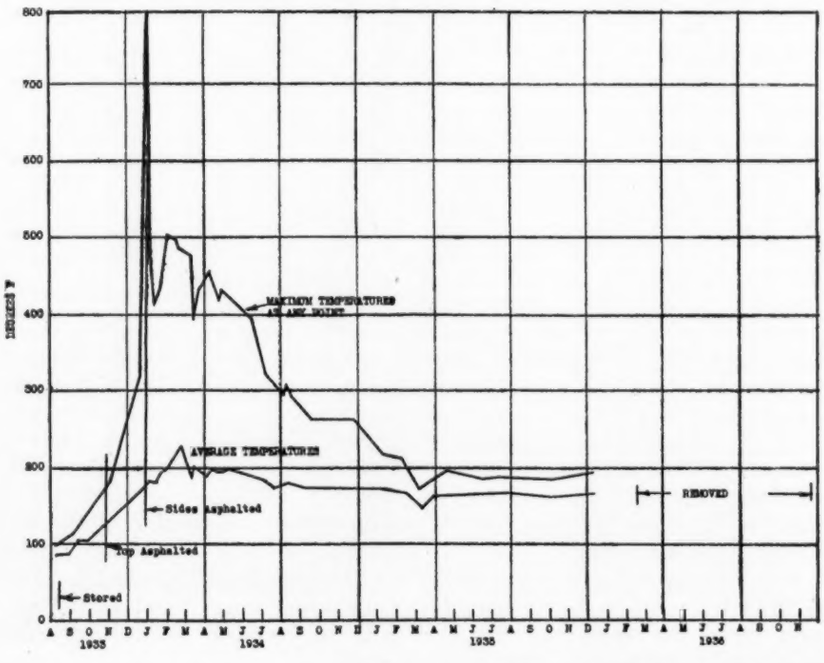



**Fig. 1—Rapid heating arrested by asphalting**

Temperature increased rapidly in spite of packing the coal to 18 per cent greater density. Making the top airtight did not influence the rate of temperature increase. Later asphalting of the sides smothered the fires and reversed the temperature trends.

coal bridge so that it could apply the asphalt when suspended in the air over the slopes and traversed as necessary by movement of the bridge. Fig. 2 shows this equipment in operation.

The sides were first raked smooth, a 4-in. layer of $^5/_{16}$-in. screenings, requiring 1200 tons, was applied and raked very smooth, and then the asphalt applied before snow interfered. The asphalt was of the "cut-back" type with 110 penetration at 77 F, and was previously heated in the tank car. It was applied at the rate of approximately $1^1/_3$ gal per square yard, causing a coating about $^1/_8$ in. thick. The total cost of covering the complete pile was about 1 per cent of the coal cost. Table I gives data of packing and asphalting.

### *Results of Asphalting*

Immediately after asphalting the sides, the "hot-spot" decreased in temperature from 800 F to 400 F, thus proving the effectiveness of the work. For the first time in several months, lessening anxiety for the safety of the pile was enjoyed. Average temperatures of the pile did not decrease immediately, apparently because of heat conduction from "hot-spots" removed in distance from the nine measuring pipes. Orsat measurements showed as low as 1.6 per cent oxygen in the gases under the asphalt covering at the top center of the pile. Temperature gradient measurements indicated about 2 per cent heat loss per year when the average pile temperature was 180 F.

"Bleeding" of the asphalt used on the sides, which was apparently different from that applied on the top, necessitated patching. Emulsified asphalt applied with a hand spray was first used, then a mastic of asphalt and coal, and finally fine coal alone was employed with best success.

Because the foot of the slopes had not been "trimmed," by removing the lump coal to the top of the pile and packing it there, small surface fires resulted and required almost continuous attention. These were worse after high winds or heavy rains. Screenings, denoted as $^5/_{16}$-in. carbon (see Table II), were found effective in stopping these fires. The few $^5/_{16}$-in. lumps contained in this fine coal reduced wind erosion without permitting air-flow resistance to be too low for effectiveness. A total of 800 tons, or $^2/_3$ per cent of the pile weight, was used for this purpose.

TABLE I—PACKING AND ASPHALTING OF PORT WASHINGTON COAL PILE

| | |
|---|---|
| *Coal Data* | |
| Tons in storage | 121,174.4 |
| Height of pile, ft. | |
| Maximum | 50 |
| Average | 48.7 |
| Dimensions of base, ft. | 350 × 350 |
| Dimensions of top (before grading) | 225 × 225 |
| Density of packed coal, lb per cu ft. | 63.2 |
| Usual density of unpacked coal piles, lb per cu ft. | 53.4 |
| Per cent packing | 18.5 |
| *Asphalt Data* | |
| Top of pile asphalted | |
| Area, square yards (includes part of slope) | 7,000 |
| Gallons of asphalt used | 9,500 |
| Gallons per square yard | 1.35 |
| Sides of pile asphalted | |
| Area, square yards | 10,500 |
| Gallons of asphalt used | 13,000 |
| Gallons per square yd | 1.25 |
| Total asphalt used, gallons | 22,500 |
| Gallons per square yard | $1^1/_3$ |
| Average thickness of coating, inches | $^1/_8$" |
| Asphalt, per cent of coal weight | 0.07 |
| Asphalt, per cent of coal heating value | 0.1 |
| Approximate total labor and materials cost, per cent of coal cost | 1 |
| *Per cent Oxygen in Gases Beneath Asphalt* | |
| At corners, near top of pile | 10% |
| At center, near top of pile | 1.6% |

### *Pile Temperatures*

Though average pile temperatures were prevented from increasing further, by asphalting, they did not start decreasing until the spring wind and rain period was passed. Leaks were undoubtedly sustaining heat losses. The pile cooled slowly throughout the summer and the following winter to an equilibrium temperature of 165 F, at which value the coal was removed during an eight-month period without trouble. The asphalt covering pulverized and burned satisfactorily except on one or two occasions, when it caused some burner clogging through not being mixed with sufficient coal.

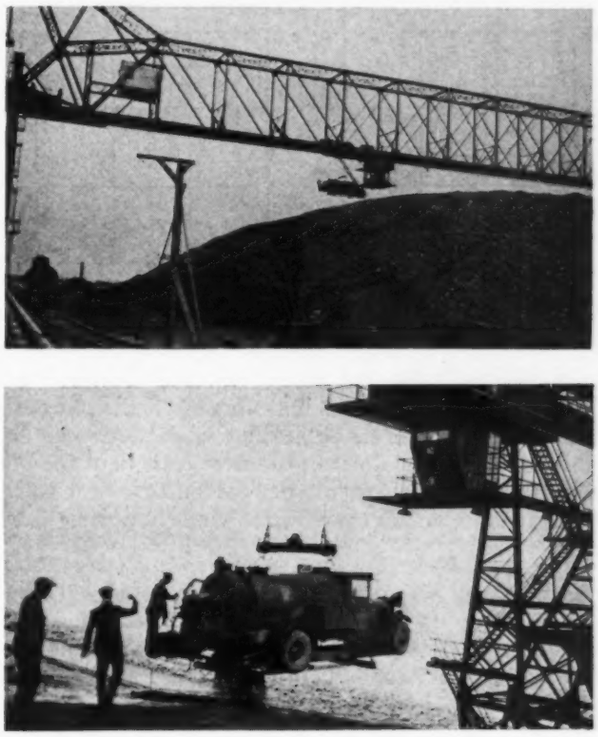


**Fig. 2—Asphalting 35-deg slopes of a large 50-ft high coal pile in winter**

Sides were "landscaped" with fine coal and the heated asphalt sprayed from the suspended truck before snow could interfere. An airtight coating about $^1/_8$ in. thick stopped burning within the pile immediately and caused the coal to decrease slowly in temperature.

### *Heat Loss of Asphalted Pile*

A loss of 4.15 per cent for three years' storage, as shown in Table III, represents fair practice, considering that it includes dust losses (which were especially high from the fine coal used for patching), and loss from local fires at the base of the pile due to lack of initial trimming. It does not credit 0.2 per cent sensible heat difference between receipt and usage, and, of course, applies to a pile that undoubtedly would have burned seriously had not fireproofing been employed.

Had not the obvious dust and small-fire losses occurred, the experience would have afforded excellent data of losses from spontaneous heating alone. Heat value samples were collected in accepted manner for every 500 tons, both when storing and reclaiming for plant usage. The initial weight reported is that of the shipping association at Lake Erie ports and heat values for the reclaimed

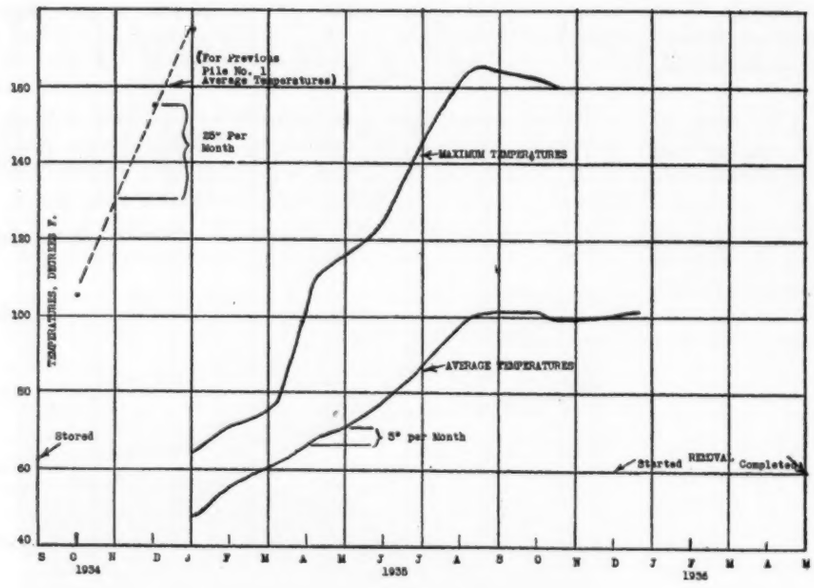



**Fig. 3—Fine coal covering keeps pile relatively cool**

**The rate of heating is only one-fifth that in the first pile, and the equilibrium temperature is 65 deg lower. Some solar heating can be expected and some air leaks undoubtedly existed. No measurable heat loss occurred in 15 months' storage.**

coal are those upon which station economy was computed. Inspection of Table III shows that the measured ash contents are quite close, indicating fair sampling accuracy. Dry-combustible heating value decreased because of oxidation. Coal in the west corners of the pile was several per cent lower in dry-combustible heat value, which again indicates the effect of winds in causing heating.

### Second Project (Fine Coal Covering)

Storage of 40,000 tons in another 50-ft high pile for approximately $1^1/_3$ yrs provided a second experience of interest.

Lesser sulphur (1.5 per cent as compared with 2.8) and a location less exposed to high winds (in the yard of a Milwaukee coal company between other piles) made this project easier, though are not alone explanatory of the results obtained. Similar coal stored in nearby piles

TABLE II—COAL FINENESS DATA

| | Per cent through, mesh | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 200 | 100 | 48 | 28 | 20 | 10 | 6 | 3 | 1/2" |
| Pocohontas Screenings | 3.2 | 4.4 | 6.4 | 10.4 | 12.6 | 25.4 | 47.8 | 80.6 | 98.6 |
| Kentucky Screenings | 6.2 | 9.4 | 14.8 | 21.6 | 26.8 | 38.4 | 51.8 | 70.0 | 92.6 |
| Illinois 1/16-in. Carbon | 4.6 | 7.9 | 13.6 | 22.0 | 28.8 | 47.2 | 76.0 | 88.0 | 100 |
| Illinois minus 48 mesh | 36.4 | 48.8 | 69.5 | 85.8 | 93.6 | 99.0 | | | |

in the coal company's regular manner fired in less than six months, requiring removal of the hottest coal and much rehandling of the remainder.

### *Fine Coal Versus Asphalt for Sealing*

Experience with fine coal for maintaining tightness of the first pile on which asphalt had deteriorated by "bleeding" and small fires resulted, suggested that fine coal be used exclusively for the second project. This naturally prompted an investigation of the air-tightness of fine coals.

Table IV indicates the results of laboratory tests to determine the resistance to air flow of various coals with widely different finenesses and with different degrees of packing. The test data plotted as straight lines on logarithmic paper.

Pocahontas screenings were found 200 times as conducive to air flow as "minus 48-mesh" coal available

TABLE III—HEAT-LOSS AND GENERAL DATA OF THREE LARGE PILES

| Project Number | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Time of storage, years | 3 | $1^1/_3$ | 3/4 | 1/4 Planned |
| Approximate tonnage | 120,000 | 41,000 | 45,000 | 75,000 |
| Size of coal | Mine run (Dust to 24 in.) | 2-in. Screenings | 2-in. Screenings | 2-in. Screenings |
| *Fire-proofing method* | | | | |
| Packing | Yes | Yes | No | No |
| Air-tight covering | 1/8-in. asphlat | 12-in. fine coal | No | 12-in. fine coal |
| *Pile Dimensions* | | | | |
| Height, feet | 50 | 50 | 45 | 50 |
| Length & width at base, feet | 350 × 370 | 180 × 310 | 180 × 410 | 250 × 400 |
| Slope, approximate | 35° | 35° | 35° | 30° |
| Date of completing storage | Aug. 1933 | Sept. 1934 | May 1935 | Nov. 1936 |
| Date of completing removal | Nov. 1936 | April 1936 | May 1936 | |
| *Coal Analyses* | | | | |
| *As piled,* | | | | |
| Moisture, per cent | 2.08 | 3.90 | 3.23 | |
| Volatile matter, per cent | 38.44 | 34.93 | 36.19 | |
| Fixed carbon, per cent | 53.18 | 56.06 | 55.07 | |
| Ash | 8.38 | 9.01 | 8.74 | |
| Sulphur | 2.85 | 1.52 | 2.27 | |
| Btu per lb dry combustible | 15,106 | 14,900 | 15,163 | |
| Btu per lb dry coal | 13,840 | 13,568 | 13,841 | |
| Btu per lb "as received" | 13,552 | 13,035 | 13,394 | |
| *As Removed* | | | | |
| Moisture, per cent | 3.20 | 5.81 | 4.36 | |
| Volatile matter, per cent | 36.45 | 34.05 | 34.74 | |
| Fixed carbon | 54.91 | 56.94 | 55.74 | |
| Ash | 8.64 | 9.01 | 9.52 | |
| Sulphur | 2.62 | 1.42 | 2.39 | |
| Btu per lb dry combustible | 14,897 | 15,050 | 15,016 | |
| Btu per lb dry coal | 13,610 | 13,695 | 13,587 | |
| Btu per lb "as received" | 13,176 | 12,899 | 12,995 | |
| *Heat Value Loss, per cent* | | | | |
| Per lb of dry combustible | 1.38 | 1.0 gain | .97 | |
| Per lb of dry coal | 1.66 | .93 gain | 1.85 | |
| Per lb of "as received" | 2.77 | 1.04 loss | 3.00 | |
| *Total Weights, $10^6$ lb.* | | | | |
| As piled | 248.296 | 82.93 | 91.38 | |
| As removed | 244.778 | 83.90 | 93.26 | |
| As removed corrected for $H_2O$ | 247.52 | 82.4 | 92.2 | |
| Per cent loss, corrected for $H_2O$ | 0.31 | 0.64 | 0.9 gain | |
| *Total Heating Value, $10^{12}$ Btu* | | | | |
| As piled | 3.3649 | 1.081 | 1.224 | |
| As removed | 3.2251 | 1.082 | 1.212 | |
| Loss | .1348 | .001 gain | .012 | |
| Per cent Loss | 4.15 | Negligible | 1.0 | |

from an Illinois mine having a dedusting process. Approximate calculations indicated that a foot of fine Pocahontas screenings would not appreciably reduce the air flow through a 200-ft wide pile of 2-in. screenings, nor would it reduce air flow below the point that the heating rate would be less than the heat dissipation rate. Moreover, Pocahontas screenings are not impervious to water.

Water is necessary for combustion of the sulphur, which acts as the pilot light that heats the pile to the point where carbon reactions begin. Thus:

$$2FeS_2 + 2H_2O + 7O_2 = 2FeSO_4 + 2H_2SO_4 + 1{,}155{,}000 \text{ Btu /lb Mol.}$$

Experience with packing $^5/_{16}$-in. carbon coal (a form of screenings with much fine dust, see Table II) showed that puddles of water collected and stayed in depressions of the packed surface for days. Furthermore, piles of this coal were unusually susceptible to erosion from rains, because little water soaked into them.

Application of 12 in. of the "minus 48-mesh" material on the levelled pile, and covering it with 12 in. of large-size screenings to pack it and to prevent wind and water erosion, was concluded to be a practical and effective means of fire prevention. Without depending upon the helpful effects of settling and of the closing of voids in the fine coal by water, the 12-in. layer would change the air flow characteristics of the pile of coarse screenings to that of fine screenings.

Estimates indicated that the fine-coal seal would be appreciably less expensive than asphalting. Actual costs of fireproofing a more recent pile (Project No. 4) proved this true, for they totalled $^2/_3$ per cent of the coal cost. Asphalting requires considerable close scheduling that can be disrupted by unfavorable weather, and differences in asphalt quality present an important variable that can cause serious trouble.

### *Method of Applying Fine Coal*

Sides of the pile are raked fairly smooth by hand labor. Moving coal down the slope to transfer peaks into hollows is done with little effort because the coal is near its angle of repose. If adequate storage space is available, initial piling at slightly less than the angle of repose, say, 5 deg less, assists application of the fine material, which tends to flow like aerated pulverized coal. The top of the pile is levelled most efficiently with a caterpillar tractor equipped with a "bull-dozer." A ramp can be made for the tractor when building the pile, or it can be elevated by the coal bridge.

Ten-ton bucketfuls are deposited at designated intervals, starting at the base of the slopes, and levelled by hand to approximately 12 in. thickness. Before wind can blow it away, the fine coal is covered with lump coal, or screenings, from other sources or from other uncovered parts of the same pile. Edges should remain uncovered, so that joints with later work will be airtight. Leaks become evident by the issuance of tell-tale moisture-laden air that appears as steam on cold days. These should be stopped.

Application of the fine coal is a dusty process that is done best in the absence of winds. Once covered with lump coal, the pile is positively dustless. Upon reclaiming, the fine coal has lost its dustiness because of slow moisture absorption. A pile of "$^5/_{16}$-in. carbon" was deliberately wetted by building dikes of coal around its flat top to trap rain water, and the dikes were opened after a period long enough to moisten all the coal in the pile.

If coal of the fineness indicated in Table II (minus 48 mesh) is not readily available, preparing it on the site with a semi-portable crusher might be practical. When shipping minus 48-mesh coal in flat cars, a superficial layer of small lump coal is necessary to retain it in the car during transit.

TABLE IV—RESISTANCE OF VARIOUS COALS TO AIR FLOW

Pressure Loss (inches of water) per Foot of Coal for Various Air Velocities*
See Table 2 for fineness data.

| Velocity, ft per second | 0.01 | 0.1 | 1.0 |
|---|---|---|---|
| Pocohontas, crushed | | .01 | .13 |
| Pocohontas Screenings | | .035 | .40 |
| Kentucky Screeings, loose, wet | | .04 | .50 |
| Kentucky Screenings, loose, dry | | .05 | .9 |
| Kentucky Screenings, moderately packed, wet | | .12 | 1.6 |
| Kentucky Screenings, hard packed, wet | | .15 | 2.1 |
| Kentucky Screenings, hard packed, dry | | .17 | 3.4 |
| $^5/_{16}$-in. Illinois carbon | | .24 | 4.2 |
| Illinois, minus 48-mesh, loose | .7 | 6.0 | 45. |
| Illinois, minus 48-mesh, 100 lb per sq ft loading | .9 | 7.5 | |
| Illinois, minus 48-mesh, 150 lb per sq ft loading | 1.1 | 9.0 | |
| Wet Illinois, minus 48-mesh, packed | practically air tight | | |

*Test data plotted as straight lines on logarithmic paper, 0.01 to 10. scales for velocity and 0.01 to 100 scales for pressure loss.

### *Temperatures*

The maximum temperature measured in the center of the pile was 86 F and 165 F was the maximum measured at any one point (on a corner, near the top), but this temperature later decreased for two months until removal.

Fig. 3 shows average pile temperatures, as measured at 5-ft elevations in five locations. Most of the nominal temperature increase in the $11^1/_2$ months shown occurred during the summer months. Crude estimates suggest that solar heat absorption of a coal pile, like that of a shallow lake, can readily account for appreciable temperature increases. Fig. 3 also compares the initial heating rate in this pile with that of the previous one, showing the rates to be about 5 deg and 25 deg per month, respectively.

With the exception of a few small surface fires on the exposed slope when removing the pile, no evidence of heating was ever visible. Had the pile been retained longer, like that of the first project, it probably would have reached a year-round equilibrium temperature somewhat lower than that of the first pile, for Fig. 3 shows its average temperature levelling off at 100 F.

Negligible heat loss is shown by Table III, column 2, for the total Btu before and after storage are practically identical.

A $1^1/_4$ per cent weight gain, corrected for 1.9 per cent moisture absorption, reflects a 0.6 per cent weight loss. Though the ash content checks perfectly at 9.01 per cent before and after storing, heat values of the same samples on a dry basis show a 1 per cent increase. Obviously, absolute accuracy cannot be claimed for the weight and heat value data, but the complete experience proves quite conclusively that negligible heat loss occurred.

### Project No. 3 (No Fireproofing)

Nine months' storage data of a 45,000-ton pile without fireproofing is recorded in the third column of Table III. Though only 1 per cent heat loss occurred, the pile was a source of trouble because some of it required rehandling, and the hottest spots required the earliest removal. It was considered to be in a considerably worse condition than the pile of project No. 1, and was accordingly re-

moved to the plant first. Removal of the hottest spots started six months after storage, a helpful factor not indicated by the tabulated data. On the "dry" basis, the coal showed a 1.85 per cent decrease in unit heating value but a 0.9 per cent increase in total weight, causing a net loss of 1 per cent.

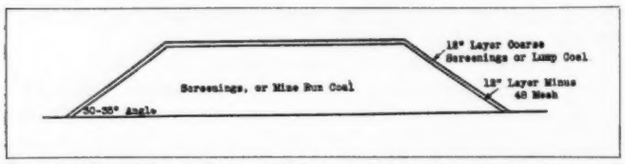



**Fig. 4—The 12-in. fine coal fireproofing layer is protected from wind and rain erosion by 12 in. of lump coal**

No foreign material is mixed with the coal, and the fine coal is usually dustless before reclaiming.

FOURTH PROJECT (FINE COAL COVERING)

Because Great Lakes navigation is closed throughout the winter months, storage of coal is necessary at the Port Washington Station. Accordingly, of the 150,000 tons approximate annual requirement, 75,000 tons was fireproofed with fine coal applied in the same manner as project No. 2 and the other 75,000 tons was used first. Adequate dock facilities permitted storage without packing. Covering with fines was not completed for two months after completion of the pile because of other work taking precedence. By that time, wisps of water vapor were visible issuing near the top corners, a sign of heating and ordinarily a warning that the "hot-spot" must be removed and cooled if trouble is to be averted. However, reliance is placed upon the nearly airtight covering causing a reduction of temperature at "hot-spots."

*Conclusions*

Sealing the sides and top of a coal storage pile to prevent or greatly reduce air circulation through it effectively inhibits spontaneous heating and permits long-time storage with small loss of heating value.

Providing an airtight coating by a continuous layer of fine coal, approaching pulverized coal in fineness, is a practical and effective means of sealing a coal pile. A second covering of lump coal prevents wind and rain erosion of the fine coal layer.

Winds are probably more responsible for air movement and heating in coal piles than is the stack effect within the pile. Sulphur, air and water provide the initial heating.

An airtight coating of asphalt actually extinguished combustion in a large pile, and changed rapid heating into slow, but positive cooling. A seal of fine coal caused the measured loss of another pile to be negligible. Fireproofing with fine coal has become an established practice where coal must be stored nine months.

---

# Production of Electricity and Consumption of Fuels

The Federal Power Commission has just issued a preliminary report on the production of electricity for public use and the consumption of fuels used in the generation of electricity in the United States for 1936.

Data compiled by the commission indicate a fuel rate of 1.45 lb of coal per kilowatt-hour as compared with 1.46 for 1935. This figure is obtained by converting the oil and gas used into equivalent tons of coal and adding this to the coal actually consumed. Inasmuch as it does not allow for the variation in the Btu content of the gas and oil as fired, and includes the output of both steam and internal combustion engines, it is only approximate.

The accompanying tables show the 1935 and 1936 production of electricity and use of fuels for the several geographical divisions of the country and the percentage change over this two-year period.

The information contained in these tables is based on figures submitted for the monthly reports issued during 1936 by the commission. The output of central stations, both publicly and privately owned, electric railway plants, plants operated by steam railroads generating electricity for traction, electricity from Bureau of Reclamation plants and the output of manufacturing plants that is sold for public use, are all included. Accurate data are received covering 98 per cent of the total and the remaining 2 per cent is estimated.

ANNUAL PRODUCTION OF ELECTRICITY FOR PUBLIC USE 1935 AND 1936

| | Production of Electricity (Millions of Kilowatt-hours) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Total | | | By Use of Water Power | | | By Use of Fuel | | |
| | 1935 | 1936 | Change (Per Cent) | 1935 | 1936 | Change (Per Cent) | 1935 | 1936 | Change (Per Cent) |
| United States | 99,398 | 113,473 | +14 | 39,968 | 40,893 | + 2 | 59,430 | 72,580 | +22 |
| New England | 6,914 | 7,496 | + 8 | 2,950 | 2,852 | − 3 | 3,964 | 4,644 | +17 |
| Middle Atlantic | 25,905 | 29,281 | +13 | 7,836 | 7,348 | − 6 | 18,069 | 21,933 | +21 |
| East North Central | 22,833 | 26,384 | +16 | 2,686 | 2,310 | −14 | 20,147 | 24,074 | +19 |
| West North Central | 6,588 | 7,026 | + 7 | 2,148 | 1,497 | −30 | 4,440 | 5,529 | +25 |
| South Atlantic | 11,430 | 13,746 | +20 | 6,495 | 7,137 | +10 | 4,935 | 6,609 | +34 |
| East South Central | 4,206 | 4,985 | +19 | 3,458 | 3,865 | +12 | 748 | 1,120 | +50 |
| West South Central | 4,879 | 5,634 | +15 | 286 | 168 | −41 | 4,593 | 5,466 | +19 |
| Mountain | 3,518 | 4,309 | +22 | 2,681 | 3,256 | +21 | 837 | 1,053 | +26 |
| Pacific | 13,126 | 14,612 | +11 | 11,428 | 12,460 | + 9 | 1,698 | 2,152 | +27 |

ANNUAL CONSUMPTION OF FUELS IN GENERATING ELECTRICITY FOR PUBLIC USE

| | Coal (Thousand Net Tons) | | | Oil (Thousand Barrels) | | | Gas (Million Cu Ft) | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1935 | 1936 | Change (Per Cent) | 1935 | 1936 | Change (Per Cent) | 1935 | 1936 | Change (Per Cent) |
| United States | 34,807 | 41,973 | +21 | 11,393 | 14,110 | +24 | 125,239 | 155,525 | +24 |
| New England | 2,025 | 2,380 | +18 | 2,622 | 3,198 | +22 | 0 | 0 | 0 |
| Middle Atlantic | 11,133 | 13,129 | +18 | 3,356 | 4,868 | +45 | 1,602 | 4,773 | +198 |
| East North Central | 13,627 | 16,274 | +19 | 145 | 183 | +26 | 9,476 | 13,359 | +41 |
| West North Central | 3,041 | 3,627 | +19 | 785 | 927 | +18 | 25,002 | 30,727 | +23 |
| South Atlantic | 3,033 | 4,076 | +34 | 2,331 | 2,548 | + 9 | 1,432 | 2,682 | +87 |
| East South Central | 599 | 880 | +47 | 98 | 112 | +14 | 4,488 | 5,465 | +22 |
| West South Central | 764 | 889 | +16 | 768 | 903 | +18 | 60,895 | 72,594 | +19 |
| Mountain | 585 | 718 | +23 | 294 | 370 | +26 | 4,304 | 5,085 | +18 |
| Pacific | 0 | 0 | 0 | 994 | 1,001 | + 1 | 18,041 | 20,840 | +16 |

# Some Factors Influencing Design of Pulverized-Coal-Fired Steam Generating Units*

By OTTO de LORENZI

Combustion Engineering Company, Inc.

**The design of a pulverized-coal-fired steam-generating unit is influenced by many factors, among the more important of which are the extent and character of the load, the quality and characteristics of the coal, available space and steam conditions. Selection of furnace type, its proportioning and the form of firing are discussed with reference to load and fuel, as well as the disposition of heat-absorbing surface and regulation of superheat.**

FIRST of all, the type of load has a most important bearing on the design of the furnace that is to be employed. This is especially true in public utility plants, where new units frequently operate on base load until such times as newer and more efficient units are installed. They are then assigned to operate on variable load, following the usual type of station load curve, and may have many stand-by hours during the daily operating cycle.

Since every type of boiler has a well defined limit as to the amount of steam it is possible to generate per section of width, the maximum load to be carried will thus determine the minimum furnace width it is permissible to employ.

The furnace volume, as well as radiant-heat-absorbing surface, are factors of both the continuous and the maximum peak loads. The volume is determined by the amount of coal it is necessary to burn so as to generate the required heat liberation in the furnace at the continuous load point. The duration of the maximum peak will begin to enter into the picture if it is greater than two hours. The disposition of the radiant-heat-absorbing surface, as well as its extent, are a direct function of the sustained furnace temperature brought about by the load conditions. The extent and distribution of the heat-absorbing surfaces beyond the furnace are also decidedly influenced by the character and the extent of the operating load.

The maximum overall design efficiency, which it is permissible to purchase and yet earn a reasonable return on the plant investment, is determined from the load factor and the price of fuel.

It might seem, from these general statements, that in order to properly design a steam-generating unit, it is only necessary to know the load characteristics. This, however, is far from being the truth. While the load characteristics do serve to influence all of the design features, it is only when they are taken into consideration with other factors that it is possible to arrive at the correctly proportioned unit. Therefore, in the discussion that follows, there is a continual recurrence of reference to load conditions.

* From a talk before the Engineering Society of Western Pennsylvania.

### *Coal to Be Burned*

Of greatest influence, after load characteristics, is the type and quality of the coal to be burned. In practically all cases there are available a number of coals of widely differing quality. It is, therefore, necessary to provide designs that will handle this variation in fuels without materially handicapping the operation of the unit. The coal factors which must receive the greatest consideration are: moisture, volatile matter, ash, fusion temperature of ash and grindability.

Moisture and grindability are the determining factors in the selection of the milling equipment as to capacity. However, volatile matter also exerts some influence, since it determines the fineness of grinding and therefore, indirectly, the capacity requirements. The power consumption of the milling equipment is also directly dependent upon these factors.

Moisture has an additional influence in that it determines the minimum air temperature permissible at the mill inlet to effect the necessary drying during pulverization.

Volatile matter in coal is the qualtity that has the greatest influence on burning characteristics. A low-volatile coal will generally ignite and burn slowly, since it has a high fixed carbon content. A high-volatile coal, on the other hand, will increase in "flashiness" as the volatile content increases. These burning characteristics must, therefore, be taken into consideration since they affect ignition, burner design, air distribution, length of flame travel, etc.

Low-volatile coals are most ideally suited to a furnace design and burner arrangement that provides for long flame travel and low rates of heat liberation. The extreme example is anthracite. In pulverized form, it is

best burned in a furnace where the coal and carrier air stream are introduced through a multiplicity of relatively small burners, vertically downward into a large furnace. The resultant flame, turning back on itself, after traveling downward for twenty or more feet, then enters the boiler heating surface at, or above, the elevation of the burners. If low carbon loss, as well as low maintenance are desired, the heat liberation rate should not exceed 22,000 Btu per ft. As the volatile content increases, the rates of heat liberation may be increased and the type of firing changed so as to use the horizontal turbulent-type burner. The foregoing comments apply principally to coals having a volatile content between 7 and 28 per cent.

In the case of fuels having a low volatile content, it is also necessary to give consideration to burner design. Since ignition is slow, the velocity of the coal and air mixture entering the furnace must also be relatively slow, so that rate of flame propagation and velocity of mixture are balanced to give a steady, pulsationless flame, instead of one that is continually trying to pull away from the burner. This condition of flame pulsation is almost entirely absent in vertical firing, since only a part of the air for combustion is admitted through and around the burner, thereby providing a rich mixture at the point of ignition. The remainder of the combustion air is admitted to the fuel stream after it has been fully ignited and all danger of the flame pulling away from the burner is passed.

In the case of high-volatile coals, a burner arrangement which provides for some form of horizontal turbulent firing will produce the best results. Here again it is necessary to balance the velocity of the coal and air stream against flame propagation. The type of burner most suitable for these coals is one in which violent turbulence is continued after the fuel and air enter the combustion chamber. In this manner combustion is extremely rapid and, as a result, it is possible to operate at higher rates of heat liberation in the furnace. The tangential or corner-firing arrangement of burners is one which makes fullest use of this continued turbulence. This arrangement has still another advantage in that the flames, in sweeping the water-cooled wall surfaces, transmit heat by convection, in addition to the radiant transfer, as a result of which there is greater heat absorption and a lowering of furnace temperature. This difference in furnace temperature may be as great as 300 deg F, in similar furnaces having identical volume and the same amount of wall-cooling surface, but using in one case horizontal turbulent burners and in the other tangential burners.

The ash content and the fusion temperature of ash are usually joint factors in the determination of a number of design factors. Generally, it may be stated that where the ash content of a coal is low the fusion temperature is relatively high, that is above 2200 F. Where the ash content is high the fusion temperature is generally below 2400 F. For preliminary design purposes, in the absence of specific data as to fusion temperature of the ash, the foregoing may be assumed. However, when designing a furnace to take advantage of the highest possible rate of heat liberation, it is necessary to have definite knowledge of the range in ash-fusion temperature of the coals that will be burned. With this knowledge it is possible to set the proper furnace volume, with the correct proportion of furnace-wall cooling surface, so that the gases entering the boiler are below the slagging temperature of the poorest coal to be burned.

At this point another design factor is injected, namely, the maximum temperature of the superheated steam. If the temperature of the gases leaving the furnace are too low, it may be necessary to provide an excessively large superheater to meet the desired steam temperature curve at various rates of evaporation. Here the question of load also enters the problem. If the maximum peak load is of relatively short duration, it is possible to operate the furnace with an exit gas temperature above the slagging point for such a period. However, at the maximum continuous load point the furnace exit temperature should not exceed the slagging temperature, if continuity of service is essential. Furthermore, when coals of high ash content are used, greater care must be exercised in seeing that the designs provide a safe margin below the slagging temperature, since the unit will be rendered inoperative more quickly than with low-ash coals.

*Gas Outlet Temperature Determines Furnace Volume*

One point in connection with furnace design which cannot be emphasized too strongly is the question of determining the correct furnace volume to be provided. Btu liberation per cubic foot per hour has been considered by many as the proper measure. This is a misconception since it does not take into account the various rates of heat absorption in the furnace walls due to variation in firing methods. The only real measure for determining correct furnace volume, allowing the heat liberation rate to fall where it may, is the furnace outlet temperature.

The design of the furnace bottom, with particular reference to the method of ash disposal, is dependent not only on load conditions, but also on the percentage of ash in the coal, as well as its fusion temperature. Generally, where the load is variable, regardless of ash-fusion temperature, the dry-bottom type of furnace is most satisfactory. In order to eliminate the possibility of fusion of the collected ash in the furnace bottom, it is necessary to provide adequate cooling means in the form of a water screen. With this type of construction, the ashpit zone may be maintained at a temperature well below 1800 F over the entire range of operation. The best performance records of steam-generating units as to continuity of service and availability are held where this type of furnace design is employed.

Where the load is relatively high and constant, and the fusion temperature of the ash is relatively low, the slag-tap type of furnace may be employed. The design may be such that the slag is withdrawn from the furnace either continuously or intermittently. It must be recognized, however, that in furnaces employing this design, repairs may not be made quickly because of the necessity of cooling a large mass of molten slag before it is possible to enter the furnace, even where a sloping type of floor construction is used.

When considering the use of the slag-tap type of furnace, it is well to carefully look into the method of firing to be employed. Generally speaking, both the horizontal and vertical types of burner have a tendency to give spotty heating of the accumulated slag on the fur-

nace hearth. On the other hand, where tangential firing is used the hearth is uniformly heated. As a direct result of the uniform heating, it is possible to tap slag and have it flow freely at a lower load point than with the other types of firing. Or, stated in another way, it is possible to successfully slag coals having a higher fusion temperature of ash with tangential firing than with other methods of firing.

As has already been pointed out, the use of tangential firing results in lower furnace temperature because of the increased heat absorption of the furnace walls.

### *Furnace Design*

Today the application of water-cooled surface to the furnace walls is carried out in such a manner that the furnace actually becomes a part of the steam-generating unit. The disposition of this surface may differ under varying conditions of fuel. The furnace walls may be so designed that they are completely covered with bare metallic water-cooled surfaces. They may be so designed that they are only partially covered by using plain tubes on varying centers as required to give specific conditions of temperature or heat absorption. In other cases it may be desirable to cover only certain wall areas. However, regardless of the amount of cooling employed, ignition will always be prompt and steady if a correctly designed burner is used.

The shape of a furnace is governed by the size and type of unit as well as the space available and the type of firing employed. It is always well to provide ample length of flame travel between the furnace hearth and the entrance to the boiler bank. The furnace volume to be provided on any given unit is determined by the maximum output, the extent of water cooling, the type of firing, the type of furnace bottom and the desired temperature at the furnace outlet. The volume referred to is always "net volume," since there are many areas in a furnace which are ineffective as far as aiding combustion. This net volume may vary from 70 to 95 per cent of the gross volume, depending upon the designs employed. The effect of furnace volume on the design of the remainder of the heating surface must always be taken into consideration. This is especially true where water cooling is employed.

The application of water-cooled surfaces to the furnace walls has still another effect. For a given rate of heat liberation per cubic foot of volume, the outlet temperatures of two furnaces may be quite different notwithstanding the fact that the percentage of wall coverage is the same. The reason for this is that the furnaces themselves may differ considerably as to their volumes. The effect of water cooling is greater where the furnace volume is small because the ratio of actual wall surface covered to the volume is greater than in the larger furnace.

### *Boilers and Superheaters*

The extent and disposition of the heat-absorbing surfaces, following the furnace, are influenced by a number of factors. Superheaters, because of the severe service imposed on them, must be adequately screened, so that the temperature of the gases entering them does not exceed safe limits. Since the furnace design has already been determined, from the operating load characteristics, it now becomes necessary to provide some protective surface in front of the superheater. This protective surface, of course, is part of the boiler surface, and its arrangement will depend on the total steam characteristics of the unit it is desired to obtain.

When a normal superheat curve is desired, one in which the steam temperature changes as the load varies, the superheater surface is selected to give a definite temperature at a specific load point. To accomplish this it is necessary to provide only sufficient protective surface to insure the necessary drop from furnace temperature to maximum permissible superheater inlet temperature, at the highest load point. The superheater surface is then definitely proportioned for the temperatures which will exist at the guarantee point.

Where a superheat curve, having a constant temperature over a definite load range, is wanted it is necessary to take the steps outlined above and also some additional ones. The superheater surface, in this case, is selected to give the desired steam temperature at the minimum load above which the temperature is to be held constant. To maintain this steam temperature constant, above this minimum load point, it is necessary to bypass an increasing percentage of the gases around the superheater as the load increases. If this is not done the steam temperature will continue to increase, since the superheater surface has been selected to give the maximum desired temperature at some low load point.

After the superheater has been selected and the amount of protective surface determined, it is necessary to provide an additional design safeguard. In actual operation there is always a possibility of something going wrong which may cause slag deposits on the boiler surface. If these slag deposits become sufficiently large the temperature in the superheater zone may increase to the danger point. To minimize this possibility the protective surface should be widely spaced and arranged to form a slag cooling zone.

The gases leaving the superheater are still at the high temperatures. It now becomes necessary to provide surface, in some form or another, to reduce them to an economically low level. The form which this surface takes will depend on the operating pressure and the type of boiler. At relatively low pressures, with either the straight- or bent-tube type of boiler, it is in the form of additional boiler surface. At high pressures with straight-tube boilers, it is in the form of economizer surface followed by air-heater surface. With high-pressure bent-tube boilers it is in the form of additional boiler surface plus either economizer and air-heater surface or air-heater surface only.

There is still one other point which is of greatest importance, in the design of a steam-generating unit, namely that its capacity is measured by what is above the water line. Immediately it becomes evident that steam-relieving area and volume are most important items. The maximum capacity that can be developed per cubic foot of steam space will depend on operating pressure and circulation characteristics of the specific boiler under consideration. Well defined limits have been established for this factor and, when exceeded, wet steam results. Of course, drum volume is not a "cure all." Proper water conditioning and internal drum baffling must be given intelligent thought.

# FLUE GAS SEPARATORS

By K. HEINRICH, Berlin

**The author reviews European practice in the use of electrostatic precipitators, and mechanical separation of the wet and dry type. Some representative types are discussed and their characteristics and performances compared. The original somewhat lengthy paper appeared in "Mitteilungen" No. 56, and through the courtesy of H. N. Boetcher, of Baltimore, the accompanying abstracted translation is made available.**

THE amount of dust in the flue gas of pulverized-coal-fired boilers runs normally 3 to 7 oz per 1000 cu ft of gas, which may, however, be as high as 10 to 20 oz per 1000 cu ft with some types of coal and under certain operating conditions. Generally speaking, the flue dust of stoker-fired furnaces is appreciably coarser than with pulverized coal. Three types of flue-dust filters are in use in Europe, namely, electrostatic, wet mechanical and dry mechanical filters.

### *Electrostatic Precipitators*

Direct current at 40,000 to 60,000 volts, usually obtained through a transformer and a rotating rectifier, is applied. These precipitators eliminate especially the finer particles in which the ratio of surface to mass is high, the most favorable size being about 0.0015 in. The presence of soot is a disadvantage as these particles tend to stick. Uniform distribution of the flue gases is important. The negative charging electrodes are made of chrome-nickel steels, often 18–8, and the grounded plate electrodes for depositing the dust are made of No. 17 Bwg sheets.

Operating experiences have shown it advisable to have some coarse dust in the deposits to avoid bridging at the filter pockets. It is not advisable, therefore, to preclean the gases in this type of separator. The gas velocities are about 6 1/2 to 8 1/4 ft per sec, with a draft loss of 0.12 to 0.4 in. of water.

The elimination of dust depends on the time during which the gas is exposed to the electrostatic effect. Tests showed an elimination of 86 to 89 per cent in 3 to 4 sec and of 95 to 97 per cent in 6 sec. Accordingly, the filter efficiency decreases with increasing load. The power consumption varies from 0.14 to 0.42 kwhr per 100,000 cu ft of gas. Shaking devices are employed for both negative and depositing electrodes. Curves showing the change of dust removal with changing load are given in Fig. 1 for different precipitator sizes. The percentage decreases with increasing load and gas velocities, especially with units of insufficient size.

### *Wet Mechanical Separators*

These separators which also give high efficiencies of 90 to 95 per cent have been developed largely in England. This appears to be due to the stress laid there on the removal of sulphuric acid from flue gases and to the fog-forming properties of fine dust particles, especially in London. As the rain in several British cities has a pH of 3 to 6, removal of acids appears to be quite advisable. The sulphuric acid necessitates the use of highly corrosive-resistant materials in those parts of the separators which are in contact with the acidified water. Corrosion-resisting steels are used as well as linings of concrete, lead, hard rubber, corrosion-proof masonry, etc.

Another problem of importance is the removal of the dust from the water. Unless large amounts of water are available and can be discharged with the eliminated dust, it is necessary to have large settling basins.

The simplest type of wet mechanical separator employs fine sprays from nozzles. According to British experiences, the installation in horizontal ducts is preferable to nozzles in vertical ducts. The water should be as warm as possible without evaporation of appreciable quantities, temperatures of 100 to 160 F being used. The addition of soap (about 1 lb to 60–75 gallons of water) is sometimes needed to break down the surface tension of the dust. The use of circulated water is advocated, on the basis of experience in briquetting plants. Approximately 1/2 per cent of the dirty water is cleaned

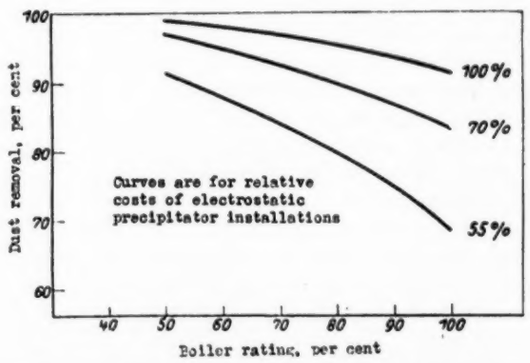



**Fig. 1—Degree of dust removal plotted against boiler loading for different sizes of electrostatic precipitators**

to a residual content of total solids of 10 to 20 per cent and added to the spray water. It is advisable, in this case, to use tangential types of nozzles to avoid clogging.

The use of spay nozzles alone involves high water consumption, about 7 to 15 gallons per 1000 cu ft of gas. The addition of suitable plate or tray arrangements will cut the required amount of water in half.

The desire to lower the water consumption still more has resulted in designs combining wet separators with dry separators in which coarse particles are removed by centrifugal or mass forces and the remainder is washed

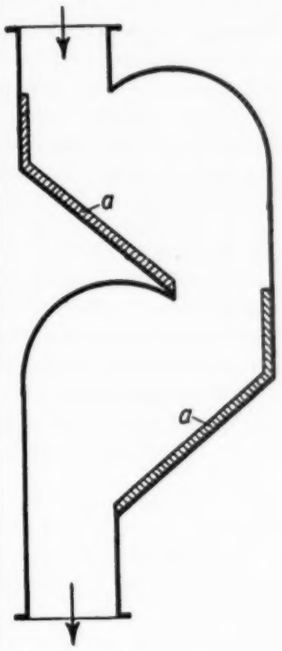



**Fig. 2—Finow dust catcher**
*a.* Wetted dust removal surfaces

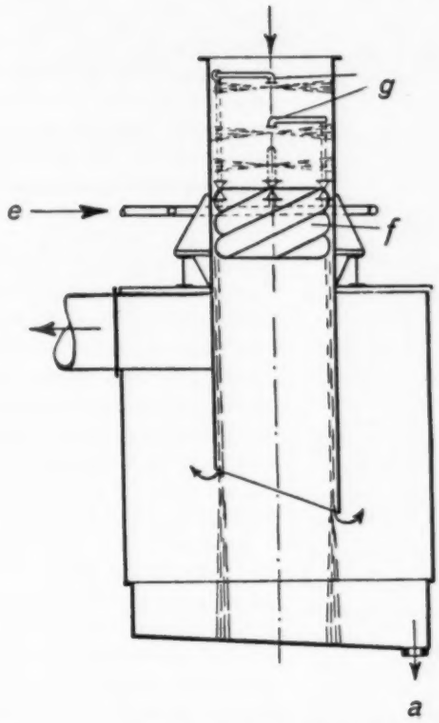



**Fig. 3—Frey wet-type dust catcher**
*a.* Muddy water outlet
*e.* Water inlet
*g.* Spray nozzles
*f.* Spiral

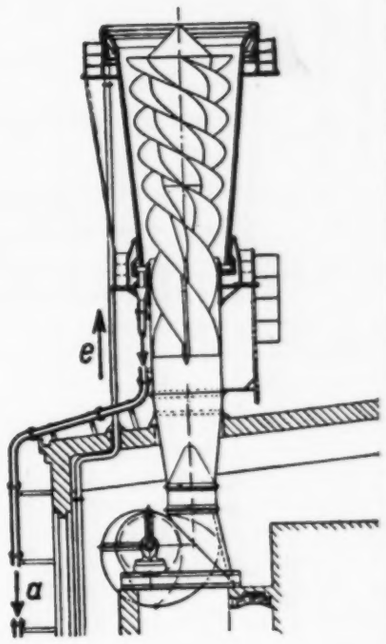



**Fig. 4—Kroger wet-type dust catcher**
*e.* Fresh water
*a.* Water outlet

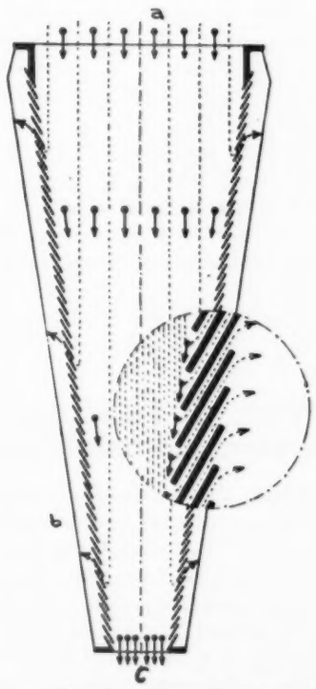



**Fig. 5—Filtrey flue gas cleaner**
*a.* Flue gas inlets
*b.* Flue gas outlet
*c.* Dust outlet

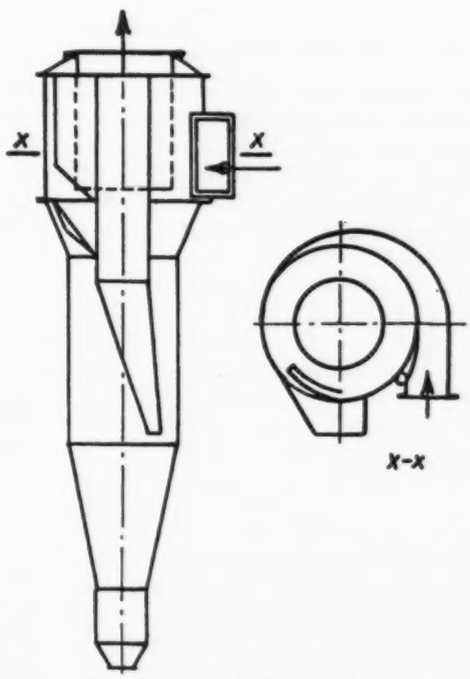



**Fig. 6—Single cyclone of Van Tongeren type**

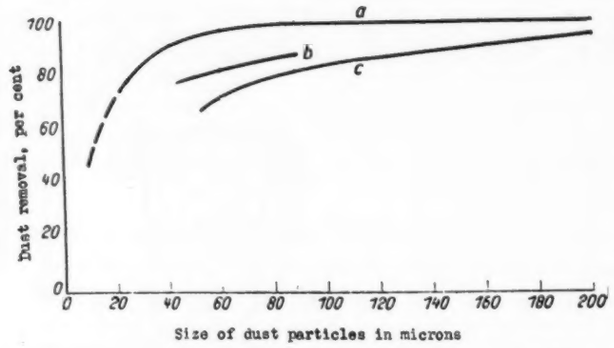



**Fig. 7—Removal of dust by dry mechanical method as a function of particle size**

*a.* Double cyclone type
*b.* Centrifgal type
*c.* Fan Removal

away in the wet section. The separator shown in Fig. 2 has removed 80 per cent of the dust with a water consumption of 0.4 gallons per 1000 cu ft of gas. Service data given for the separator shown by Fig. 3 indicate water requirements of $1^1/_2$ to $2^1/_4$ gallons per 1000 cu ft of gas, with a removal of 98 per cent of the dust, of cooling of the gases from 400 F to 320–340 F, an increase in dew point of 9 to 18 deg F, and a draft loss of 0.6 to 1.2 in. of water. The walls of this separator, excepting the cast-iron intake pipe, are usually built of brick. The separator shown by Fig. 4 requires 0.9 gallons of water per hour per foot of the circumference at the separator outlet. Operating difficulties have been experienced with this type of separator whenever an approximate gas velocity of 33 ft per sec was exceeded since water spray formed and caused flue dust to clog the screw.

### *Dry Mechanical Separators*

Settling chambers, usually with intermediary walls have been satisfactory for the elimination of coarse particles especially from grate-type furnaces. Gas velocities of about 7 ft per sec, draft losses of 0.12 to 0.2, and length of sections not less than 23 ft, usually 27 to 30 ft, are customary conditions. The total length of the separator is about 33 to 40 ft, arranged often in a ring around the stack.

Normally, dry separators make use of centrifugal force. For best effect it is necessary to concentrate the dust in a bypassed part of the flue gas flow. The "Filtrex" separator, shown in Fig. 5, permits high gas velocities of as much as 75 to 85 ft per sec since the dust particles do not pass through the cleaned gases. Many designs make use of the induced-draft fans. Simple cyclone-type separators are not satisfactory for large gas quantities, because of the high draft losses. They are used, therefore, mainly in special designs giving long gas passages and high velocities. A peculiar service behavior has been observed with separators of the type shown in Fig. 6 which remove the dust taken out during the first revolution of the gas separately. While types of cyclone separators show increasing efficiences with increasing dust concentrations, this "Van Tongeren" separator, however, shows decreasing efficiencies. For instance, an efficiency of 77 per cent was determined with a dust concentration of 0.5 oz per 100 cu ft of gas, and 72 per cent with 2 oz per 100 cu ft.

Cyclones are used frequently, two in series, or to clean bypassed gases containing flue dust concentrated by other types of separators. These double separators are often combined. In this case, 2 or $2^1/_2$ rotations of the gas stream are usually sufficient. The distribution of the separation between the two separators depends on the fineness of the dust. The flue dust from stoker furnaces showed up to 98 per cent of the eliminated dust to be deposited in the primary separator and from pulverized-coal furnaces 80 to 90 per cent.

Figs. 7 and 8 show comparative curves for different types of separators and indicate the influence of different factors. Fig. 7 shows the changes in separation efficiency with increasing particle size for (*a*) double-cyclone separators, (*b*) centrifugal separators and (*c*) induced-draft-fan type separators. Fig. 8 shows the changes in separation efficiency with increasing load for (*a*) electrostatic precipitators, (*b*) double-cyclone separators with control shutters, (*c*) double-cyclone separators with fixed shutters and (*d*) cyclone separators without shutters. The curves are not intended to give other comparisons of the various types of separators.

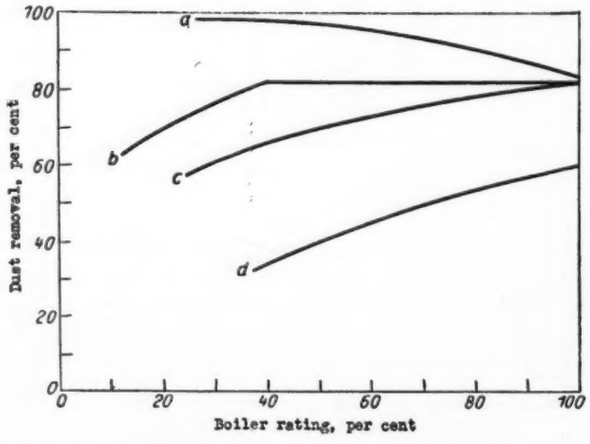



**Fig. 8—Degree of dust removal by different types as a function of boiler loading**

*a.* Electrostatic type
*b.* Double cyclone with adjustable vanes
*c.* Double cyclone with fixed vanes
*d.* Cyclone without vanes

## New York to Have Smoke Prevention Convention and Exhibition

The Thirty-First Annual Convention of the Smoke Prevention Association will be held at the Hotel Pennsylvania, New York City, from May 31 to June 5. The program has not yet been completed, but the committee is receiving the active cooperation of the New York City Health Department. In connection with the convention it is planned to hold a Fuel Burning and Air Pollution Exhibition. This will include various types of fuel-burning equipment, blowers, smoke recorders and other instruments. The principal aim of the exhibition will be to provide an educational display depicting the proper firing of fuel, the care and operation of equipment, dust fall, noxious gas emissions and the results of smoke prevention and control as carried out in certain other cities.

# Dust-Prevention Treatment of Solid Fuels

By L. D. SCHMIDT, U. S. Bureau of Mines, Pittsburgh, Pa.

**As a result of many inquiries received by the Bureau of Mines concerning dust-prevention treatment of coal and coke a survey of existing literature, supplemented by numerous communications, was undertaken by the writer. The results in greater detail, as well as references, are contained in "U. S. Bureau of Mines Information Circular 6932" which has just been issued.**

THE practice of spraying fuels with various liquids to reduce dustiness is becoming increasingly popular. Spraying equipment is being installed at many mines and preparation plants and also in retail coal yards. In a special report to the Federal Housing Administration by L. B. Sisson of Mellon Institute, the results of inspecting about 1000 retail coal yards indicated that about ten per cent east of the Alleghenies and about fifteen per cent west of the Alleghenies are equipped to treat fuel with dustproofing agents.

Many substances have been suggested for addition to fuels to decrease dustiness. Some of the characteristics that an ideal treating agent should have are: (1) effectiveness for the period of time desired; (2) low cost per ton of fuel effectively treated; (3) no harmful effects on person, clothing or equipment; (4) lack of odor in the consumer's plant; (5) no danger of flash-back or rapid evolution of obnoxious gases on firing; (6) freedom from the possibility of freezing in spraying equipment; (7) no increase in the tendency for fuels to cake or lump in freezing weather; (8) no deleterious effect on the combustion characteristics of the fuel or on the fusion point of the ash; and (9) no deleterious effect on the storing qualities of coal.

### *General Principles of Dustproofing*

Substances added for dustproofing fall into two main classes, namely, those that form a liquid film and those that form a solid or semi-solid film. The capillary forces exerted by a liquid that wets the surface of fuel particles can be utilized to cause the finer particles to cling together or to adhere to larger particles. If the liquid film on the fuel particles dries and leaves no agglutinating residue the fuel will return to its original state of dustiness. Consequently, the liquid film must last as long as the fuel is required to be dustproof. Both oil and water are liquid-film agents.

If on drying, a liquid leaves a solid or semi-solid film on the treated fuel, this residue, if it has agglutinating properties, may give sufficient protection against dusting. Solid or semi-solid films also may be applied by raising the temperature of a substance, such as paraffin, until it is liquid and then applying it to the fuel.

Comparing liquid and solid films, the solid films have, perhaps, the advantage of greater permanence, while the liquid films have the property of spreading over any new fines that may be formed by handling or shipping the fuel after treatment.

In addition to preventing dust, these various dustproofing agents are said to improve handling, storing and combustion properties of solid fuels, especially coal. In general, it is difficult to determine these secondary effects quantitatively, and insufficient experimental work has been published to warrant positive conclusions.

It has been reported that the tendency of fuel to segregate into fine and coarse fractions when handled is decreased appreciably by these agents. This is said to reduce handling losses due to accumulation of fines and also to improve handling properties in stoker hoppers. Claims are made, also, that some dust-preventing agents reduce the amount of degradation in size caused by handling.

Little information is available as to the effect of these agents on the weathering of coal during storage. The effect of the various dustproofing agents on the tendency of coal to ignite spontaneously also remains to be determined.

### *Substances Used in Treating Solid Fuels*

#### Water

In treating coal in local yards to render it dustless, water perhaps is still the most generally used dustproofing agent. Its low cost and its availability are in its favor. Its chief disadvantage is that it evaporates and leaves the fuel as dusty as before. The water should be distributed evenly throughout the fuel to obviate having to use excessive amounts for effective treatment. The use of an excessive amount of water often causes the consumer to complain that the water has been weighed as fuel. Furthermore, if wet coal is fed into stoker hoppers feed difficulties sometimes arise from arching in the hoppers. Also, an excess of moisture causes loss of the heat required to change it into steam and raise its temperature to that of the flue gases. Finally, in cold weather it is more difficult to use water as a dustproofing agent because the wet fuel itself will freeze and become difficult to handle.

#### Solutions of Hygroscopic Salts

Some salts, such as calcium chloride or magnesium chloride, will absorb moisture when exposed to air at ordinary atmospheric humidities and will eventually dissolve in this absorbed water. When sprayed on fuel, solutions of such salts form a non-drying liquid film that

stays liquid under normal atmospheric conditions. However, if the treated fuel is stored for a long time under extremely dry conditions (low relative humidity), the liquid film will dry out and deposit a semi-solid film of the salt.

Calcium chloride solution is commonly used for dustproofing fuel. Measurements of the ash-fusion temperatures of treated and untreated fuels have indicated that the addition of calcium chloride tends to decrease the fusion temperature of the ash when this temperature was high and to increase the fusion temperature when it was low. One of the chief disadvantages in the use of calcium chloride is its tendency to corrode metal parts with which it comes in contact.

From 4 to 9 lb of flake calcium chloride per ton of fuel is reported to be sufficient for effective treatment. The amount necessary increases with decreasing size of the fuel or with increasing amounts of fines. Flake calcium chloride in paper-lined bags costs $19.50 per ton f. o. b. producer, or about one cent per pound. If purchased in solution (40 per cent calcium chloride) it costs about $7.50 per ton of solution. The total cost of calcium chloride treatment at the mine has been estimated at from 5 to 12 cents per ton of coal.

### Other Water-Soluble Substances

Other water-soluble substances have been suggested and tried from time to time. These include blackstrap molasses in water solution, a by-product of glycerine manufacture containing salt and soda ash, and petroleum sulphonic acid compounds in water solution; but little information is available as to the cost per ton of coal treated. Also, waste liquor from cooking wood chips in pulp mills has been used to a considerable extent. This costs about 7 cents per gallon, and 1.75 gallons of 22 per cent solution per ton of coke is required for effective treatment. It dries to a semi-solid film on the fuel and should give relatively permanent protection against dustiness. The objection has been made that a disagreeable odor is given off when fuel treated in this way is placed on a hot fire.

### Oil

The use of oil for treating fuels to decrease dustiness is growing rapidly. It is applied by spraying from pressure nozzles as the coal is moving on a conveyor or, preferably, as it tumbles on leaving a conveyor or chute. Good distribution of the oil in a thin film over the surface of the coal particles is essential. Although oil itself is combustible and adds to the heating value of the fuel, excessive amounts must be avoided.

Numerous oils are offered for this purpose, ranging from crudes to especially compounded oils. A survey of the specifications of several oil companies as to the oils recommended for direct spraying of coal showed the following characteristics:

| | |
|---|---|
| Viscosity (Saybolt) | 100–225 sec at 100 F |
| Gravity (A.P.I.) | 18.5–25 |
| Flash point, F | 305–370 |
| Fire point | 420 F |
| Pour point | −40 to 10 F |
| Quantity | Up to 3 quarts per ton |

In general, oils of lower viscosity are easier to handle and apply evenly, while those of higher viscosity are more permanently effective. When oil-treated coal is charged on a hot fire the oil tends to vaporize, and if an excessive amount of an oil of too low flash point has been used there is danger of a flash-back upon firing.

The pour point of the oil indicates the ease with which it can be handled in cold weather.

The quantity of oil necessary to produce a given degree of dustlessness of coal depends upon the size and amount of fines present. The following table, taken from published data gives the amounts required for satisfactory dustproofing. The figures are approximate, and the amount required depends upon the type of coal treated and the permanence and degree of dustlessness required:

| Size of coal, screen openings, inches | quarts per ton |
|---|---|
| Through 3/16 | 4 to 5 |
| 3/16 to 3/4 | 3.5 |
| Through 1 | 3 |
| Through 1 1/8 | 2.5 |
| 1 to 1 1/8 | 2 |
| 1 1/8 to 3 | 1.5 |

Too much oil or uneven distribution of the oil on the fuel defeats the purpose of greater cleanliness because of drainage of oil from the fuel.

Oil can be applied cold, hot or in the form of an emulsion in water. If it is to be applied cold, higher pressures must be used since the viscosity increases rapidly with decreasing temperature.

Oil is often sprayed in the form of an emulsion in water. In this way very viscous oils can be applied from low-pressure systems. These emulsions contain from 6 to 7 per cent oil.

The cost of oil treatment has been given at 4 to 20 cents per ton of fuel treated. If the fuel is treated at a place where it can be done on a large scale the costs, of course, are lower per ton than if it is done in a small retail yard or at a plant. The available information as to permanence of dustproofing is insufficient to permit any conclusion as to how long a satisfactory degree of dustlessness will persist after treatment. However, if a suitable grade of oil has been applied the treatment should be effective for several months, even though the fuel is exposed to the weather.

With regard to secondary effects, oil serves as a preservative for metal surfaces with which the treated coal comes in contact, such as railroad cars, chutes, stokers, etc. If coal is properly treated it is said to be handled more easily and to flow more readily over grates, thereby giving a more even fire bed and permitting an even ash-pit pressure under the entire fuel bed. It has been reported that if the proper grade of oil is used on the coal the rate of oxygen absorption at storage temperatures is decreased and there will be less likelihood of spontaneous ignition.

As regards fires it should be kept in mind that the fine spray produced at the nozzles is inflammable. Even though the flash point of the oil is high, as determined by the standard procedure, the flash point of the finely divided oil in the spray could be much lower due to the large surface from which the more volatile ends could vaporize rapidly. If atomization is complete enough to give a very fine fog it is possible that an explosive mixture would be formed.

One possible source of ignition of the spray is a spark due to static electricity. Because of this possibility of sparks, care must be taken that *all* metal parts near the spray are thoroughly grounded.

Tests have indicated that the oil treatment tends to decrease somewhat the tendency for moist slack to freeze into lumps and onto the sides of cars, etc.

# STEAM ENGINEERING ABROAD

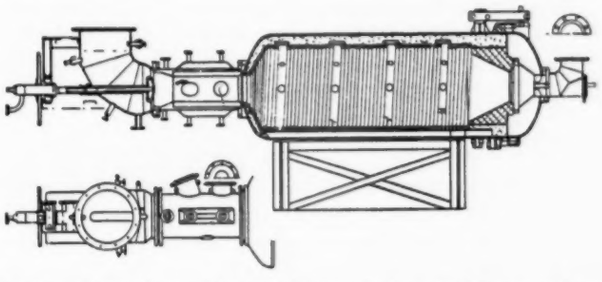
## As reported in the foreign technical press

### British Grid to Add Another 400,000 Kw

In the early part of last year the Central Electricity Board announced extensions to the public power stations of the country, which consisted of over 400,000 kw of generating plants and of boilers with an aggregate capacity of more than 5,000,000 lb of steam per hr. These were mainly intended to meet the requirements of the winter of 1938. They have since completed the arrangements necessary to meet the winter's load and have also arranged for some of the extensions, which will have to be carried out in anticipation of the increased demand during the winter of 1939. As a result, directions have recently been issued to the owners of selected stations to proceed with the installation of new turbine-alternators, boilers and cooling towers, which will add another 400,000 kw.—*Engineering*, January 15, 1937.

### Combustion under Pressure

The Russian Central Boiler and Turbine Institute is engaged in investigating the intensity of combustion in furnaces operating under pressure and for this purpose has constructed experimental equipment as shown in the accompanying sketch. The inside of the horizontal cylindrical chamber is surrounded by five coils of water tubes, each with its own water inlet and outlet. Following each of the first four coils circumferential outlets for gas communicate with the extraction chamber to permit investigation of the heat transmission in each

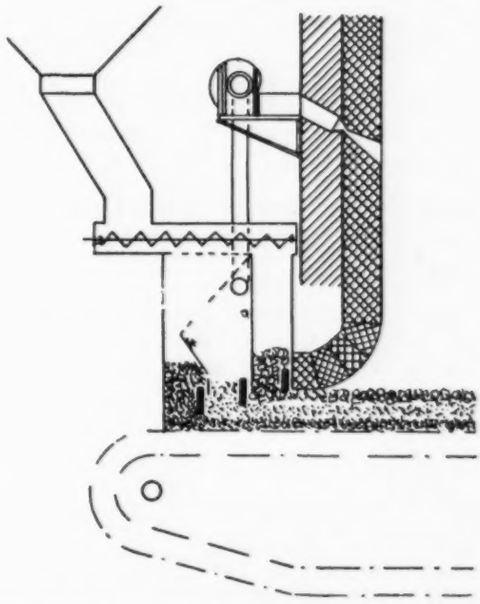


**Section through experimental furnace for studying combustion under pressure**

zone. The remaining gases are cooled by water jets in the elbow and the pressure in the combustion chamber is regulated by the throttle shown. Radiant heating conditions are studied by calorimetric measurement of the heat absorbed, direct measurement of flame radiation and determination of the efficiency of combustion. During the trials the heat developed in the combustion chamber, under 58.8-lb per sq in. pressure reached a maximum of 900,000 Btu per cu ft. It must be remembered, however, that the furnace is small with the ratio of volume to wall surface relatively small, thus rendering possible such high heat release. The investigations are described in detail in *Kotloturbostroenie*, No. 7, 1936, and reviewed in *Wärme* of November 7, 1936, and *Engineering and Boiler House Review* of January 1937.

### Burning Mixed Coal Sizes on Traveling Grate

A novel method of firing coal of mixed sizes on a traveling grate is described in *Technische Blätter*, No. 8, 1936, and reviewed in *The Fuel Economist* for December. This method, which has been recently patented in



**There is a layer of fines between two layers of coarser coal**

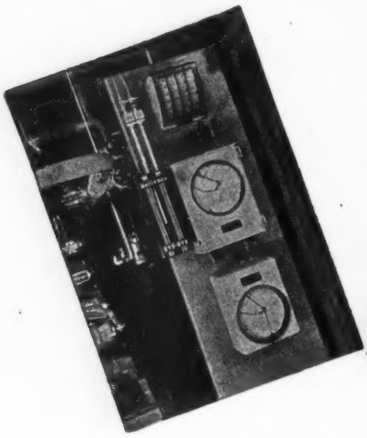
Germany, sorts the coal into sizes and feeds it in several layers on the traveling grate, the coarser coal forming the top and bottom layers with the layer of fines between.

Referring to the sketch, the mixed coal passed from the bunker down a chute onto a worm feed, the flow of which allows sizes up to 5 mm to fall through onto the inclined screen. This screen permits the fines up to 1 mm to pass through and feed into the middle section of the hopper. Those from 1 to 5 mm are diverted to the left-hand section, while the coal over 5 mm is carried by the worm to the right-hand section. Sprinklers introduce water into the middle section to moisten the fine coal. Each section of the hopper is provided with an

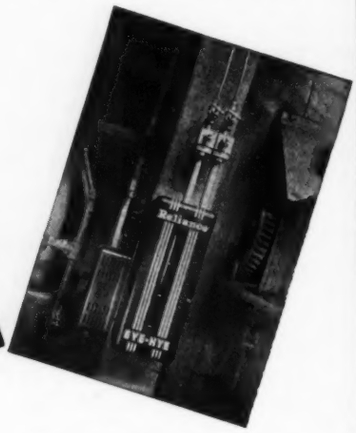
(*Continued on page 45*)

# EYE-HYE

## THE REMARKABLE NEW RELIANCE REMOTE READING WATER GAGE



Reliance Eye-Hye installation at Case School of Applied Science, Cleveland, Ohio



Reliance Eye-Hye installation at Krey Packing Company, St. Louis, Mo.

It brings a clear unmistakable reading of your boiler water level down to the power plant floor—with absolute fidelity.

It brings it down around girders, through floors, from any position, to your instrument board or wherever you want it.

It shows you the water level in a bright green, sharply illuminated.

It is perfectly accurate and it stays perfectly accurate.

EYE-HYE is a typical Reliance answer to difficult boiler water gage watching caused by excessive height, dirt, darkness or obstructions.

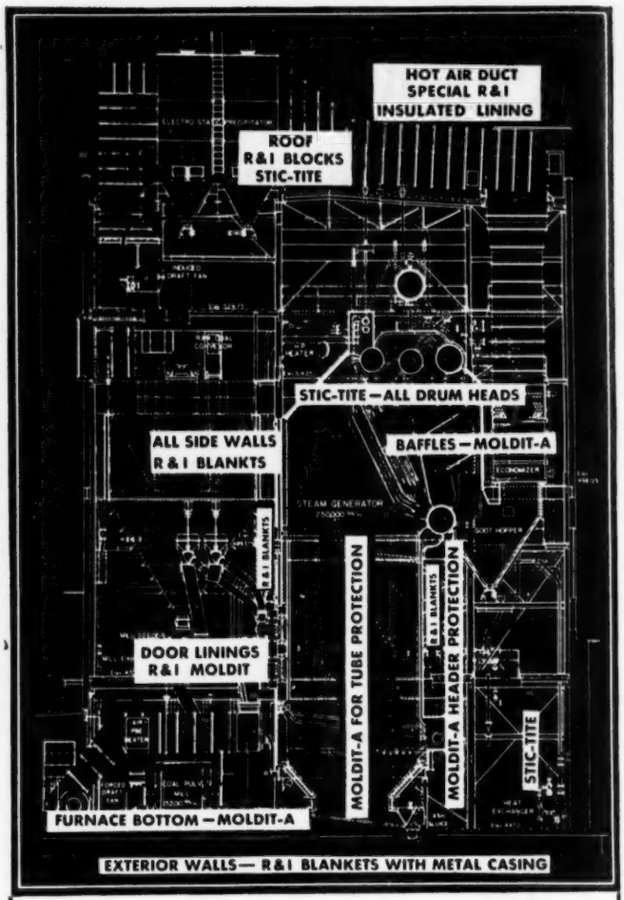
*Write for complete descriptive folder.*

THE RELIANCE GAUGE COLUMN CO.

5924 Carnegie Ave. Cleveland, O.

**Reliance** TRADE MARK REG. IN U.S. PAT. OFF.

WATER LEVELS ALARMS AND INDICATORS




## A Complete Line of Insulations and Refractory Cements FOR YOUR BOILERS

So complete is the R&I line of insulations and refractory cements there is one for every point of boiler or furnace construction. There are blankets, block and STIC-TITE—all products of exceptionally high heat saving value. There are bonding cements, monolithic cements, plastic, molding types, and cements for unusual services. Whether your plant is large or small—whether your conditions are normal or severe, there is at least one R&I product that exactly fits your requirements.

***Why not write today for complete information on products you regularly use as well as those for special purposes.***

**REFRACTORY & INSULATION CORPORATION**

*Formerly Refractory & Engineering Corp.*

381 FOURTH AVENUE NEW YORK, N. Y.

(*Continued from page 43*)
adjustable damper by means of which the thickness of the respective coal layers can be regulated.

By thus placing the fines between the layers of coarser coal they can neither fall through the grate nor be carried up into the boiler passes.

## Boiler Testing by Chemical Method

Employment of chlorine measurement for boiler testing is discussed by W. S. Findlay in the January issue of *The Steam Engineer.*

To measure the evaporation of a boiler by the chemical test method requires data with respect to the following points: (1) the volumetric capacity of the boiler up to the normal water level, (2) the mean chlorine content of the feedwater and (3) the chlorine content of the boiler water at the beginning and at the end of the test. From these data the increase in the chlorine content per unit of boiler water capacity can be determined and the total quantity of chlorine that has entered the boiler during the test.

Assume, for example, that the boiler contains 5000 gallons of water and the chlorine contents of the boiler water at the beginning and at the end of the test are, respectively, 90 and 170 grains per gallon; then the total quantity of chlorine that has entered the boiler during the test is $(170 - 90) \times 5000 = 400{,}000$ grains. If the feedwater contains 8 grains of chlorine per gallon, the total amount of feedwater supplied during the test is $400{,}000 \div 8 = 50{,}000$ gallons. If the test is of ten hours' duration the mean hourly evaporation is 5000 gallons which can be readily converted into pounds per hour.

Of course, this takes no account of any chlorine that may pass over with the steam but the method is said to give very satisfactory results and to be much more convenient than a weighed evaporation test.

---

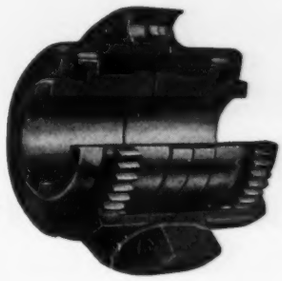
**Alex Dow,** President of the Detroit Edison Company, was recipient of the Edison Medal Award for "outstanding leadership in the development of the central-station industry and its service to the public" at the Annual Meeting of the American Institute of Electrical Engineers on January 27.

**Charles E. McQuigg** has been chosen Dean of Engineering at Ohio State University, succeeding Dean E. A. Hitchcock, retired. An alumnus of that University, Mr. McQuigg, after several years in commercial mining and metallurgical work, taught metallurgy for five years at Pennsylvania State College, and since 1921 has been with the Union Carbon and Carbide Company and has been director of research since 1934. As a lieutenant-colonel in the Ordnance Reserve he has given much time to problems connected with the development of suitable ordnance materials.

**J. F. Max Patitz,** for many years chief consulting engineer for the Allis-Chalmers Manufacturing Company, died of a heart attack on January 3. He was 71 years old and had been with the company and its predecessor, the E. P. Allis Company, since 1885. He was actively identified with the early steam turbine developments of the Allis-Chalmers Company.


# POOLE
## Flexible Couplings

**ALL METAL • FORGED STEEL**
**NO WELDED PARTS**



The Poole flexible coupling combines great mechanical strength with an unusual capacity for adapting itself to ordinary shaft misalignments. It has no springs---rubber---pins---bushings---die castings or any flexing materials that require frequent replacement.

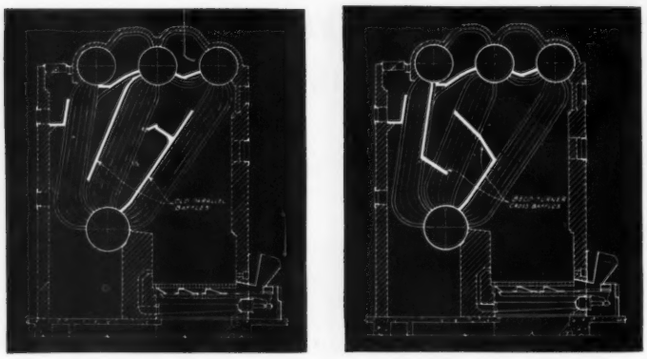
Using strong specially treated steel forgings, long wearing gears in constant bath of oil, this coupling eliminates your coupling troubles.

**OIL TIGHT • FREE END FLOAT**
**DUST PROOF • FULLY LUBRICATED**

***Send for a copy of***
***our* Flexible Coupling Handbook**

**POOLE FOUNDRY & MACHINE CO.**
**BALTIMORE, MD.**

# A message for operators of bent tube boilers



## CROSS BAFFLES *vs.* PARALLEL BAFFLES

IN VERTICAL and low-head bent-tube boilers, the installation of Beco-Turner cross baffles results in a decided increase in efficiency. In the past ten years, we have converted a large number of boilers of this type from parallel baffles to cross baffles with uniformly satisfactory results.

The prints above show two views of a 361 h.p. Stirling boiler recently converted from ordinary tile baffles to Beco-Turner cross baffles. Compare the old design at the left with the Beco-Turner design at the right. Beco-Turner cross baffles change the direction of the gases from parallel flow to the more efficient cross flow.

Where old tile baffles of conventional design are replaced with Beco-Turner cross baffles, the flue-gas temperature is decreased a minimum of 100 deg. This represents a minimum increase in boiler efficiency of approximately 3%. In a recent installation in connection with a 500 h.p. Connelly vertical boiler, Beco-Turner cross baffles reduced the flue gas temperature over 200 deg. and increased boiler efficiency 8%.

Upon receipt of blue prints showing your vertical or low-head boilers, our engineering department will be glad to prepare drawings showing our recommendations for replacing your old baffles with modern, efficient Beco-Turner cross baffles. The coupon brings your copy of the Beco-Turner catalog.

BAFFLE DEPARTMENT

**PLIBRICO JOINTLESS FIREBRICK CO.**

1855B Kingsbury St., Chicago, Ill. Offices in Over 100 Cities

**BECO-TURNER BAFFLES**

Plibrico Jointless Firebrick Co. C2-37
1855B Kingsbury St., Chicago, Ill.

Please send your free catalog, "Beco-Turner Baffles"

Firm.....

Address.....

Signed..... Title.....

No. of boilers..... H.P..... Type.....

SEND BLUEPRINTS FOR BAFFLE RECOMMENDATIONS


## ACI Holds Fuel Meeting

Appalachian Coals, Inc., was host on January 11 to more than one hundred fuel engineers and sales managers of its constituent companies who attended the Seventeenth Fuel Engineers Meeting. The principal speakers were Dr. Reinhardt Thiessen, research chemist, Pittsburgh Experiment Station, U. S. Bureau of Mines; J. J. Brennan, research engineer, Northern States Power Company; R. M. Hardgrove, engineer, The Babcock & Wilcox Company; E. P. Ogden, consulting ceramic engineer; and E. L. Greever, attorney. J. E. Tobey, manager of the fuel engineering division of ACI, who arranged the program, presided at the conference. R. E. Howe, vice president, Appalachian Coals, Inc., welcomed the engineers and congratulated them upon their cooperation in the engineering activities of ACI.

The question, "What is Coal?" was answered by Dr. Thiessen, who has spent more than 25 years in studying the paleobotany of coal. He traced the formation of coal, stating it is a process that "runs through the various ranks of peat, lignite, sub-bituminous, high-, medium-, and low-volatile bituminous, semi-anthracite and anthracite in a related chain." Many slides were shown to illustrate the various steps in coal formation and the discussion took up the scientific reasons why coals from one section of the country differ widely from products mined in other areas.

"The Fusibility of Coal Ash," was the subject of the paper by Mr. Brennan who dealt with the difficulties experienced as a result of slag and clinker formation when burning coal in furnaces of modern steam plants. He emphasized the necessity for the development of laboratory methods to aid in the selection of coal most suitable for use on particular types of equipment. He also presented a brief description of what he called "the standard method for the determination of the softening temperature of ash" and the results obtained with another method which he has found useful in classifying coals according to their slag-forming and clinkering characteristics.

"It is not the purpose of this paper," concluded Mr. Brennan, "to discuss critically the reactions causing the progressive changes which occur when an ash forms slag or clinker. That would involve an extended study of the nature of coal ash, including its chemical composition, the effect of fluxing agents, the viscosity of slag, and other factors. It is hoped that further investigation will be stimulated by the information presented in the paper. The method should be particularly useful because permanent photographic records of ash fusibility are made and a comparatively short time is required to make a test."

"Grindability of Coal from the Producers' Viewpoint" was the subject of Mr. Hardgrove's paper. He stated that the "coal producers should be actively interested in knowing the grindability of their coals, as well as competing coals." He reported that a thorough knowledge of grindability and its effect on the capacity of various types of pulverizers would help to prevent the "placing of coals in plants which have insufficient pulverizer capacity." Mr. Hardgrove expressed a hope that "coal producers will eagerly join the pulverizer manufacturers and coal users in obtaining and using" all of the factors affected by grindability, stating that this information would react to the ultimate good of all concerned.

# REVIEW OF NEW BOOKS

**Any of the books reviewed on this page may be secured from Combustion Publishing Company, Inc., 200 Madison Ave., New York**

## Thermodynamic Properties of Steam

**By Joseph H. Keenan and Frederick G. Keyes**

Since the Keenan Steam Tables were published in 1930 by the A.S.M.E., further research has been carried on both in this country and abroad as a result of which it has been possible to fill in many gaps in the former tables. These later investigations showed the skeleton tables, established as a result of the Third Steam Table Conference, to be somewhat high in the high-pressure, high-temperature ranges. These values have been corrected and are incorporated in the present tables. These have been computed from entirely new formulations of the properties of water. Most of the vapor data are taken from the Keyes' equation of state and yield a higher degree of consistency and precision than the graphic method used in the earlier tables. In addition to the tables themselves, the book sketches the data sources and mode of correlation, together with an outline of the methods used in the preparation of the tables. A large Mollier Diagram accompanies the tables and fits into a pocket in the cover.

With present power plant practice employing both higher steam pressures and temperatures it is important that the engineer use the most accurate values in these ranges, as are contained in these new tables. Price $2.75.

## A.S.T.M. Tentative Standards (1936 Edition)

The 1936 edition of the Book of A.S.T.M. Tentative Standards (1390 pages) contains 264 tentative specifications, methods of test and definitions of terms covering widely used engineering materials. A large number of the standards are included in this publication for the first time, having been approved during 1936, and a number were revised during the year and are given in their latest approved form.

New tentative specifications published for the first time in 1936 cover the following ferrous and non-ferrous materials: Alloy-steel bolting materials and carbon and alloy-steel nuts for service up to 1100 F; high-strength structural rivet steel; fabricated steel bar or rod mats and welded wire fabric for concrete reinforcement; high-carbon and quenched-carbon steel joint bars; one-wear and two-wear wrought steel wheels; seamless alloy-steel (4–6 per cent chromium); heat-exchanger and condenser tubes, and still tubes for refinery service; single- and double-refined wrought-iron bars; lightweight and thin-sectioned gray-iron castings; uniformity tests by the Preece method of coating on zinc-coated iron or steel wire; hard-drawn copper alloy wires for electrical conductors; sheet and strip phosphor bronze; seamless copper-nickel alloy condenser tubes and ferrule stock; magnesium-base alloy bars, rods and shapes; test for deflectivity of thermoflex (thermostatic metals).

In addition to the tentative standards there are included also all of the proposed revisions of formal A.S.T.M. standards, these revisions being published to elicit criticism before final adoption.

To facilitate the use of the book a complete subject index is included, listing items under the materials and subjects to which they apply; and two tables of contents are given, one listing the standards in the order they appear (grouped under general subjects) and a second listing the items in numeric sequence of serial designations.

Copies in cloth binding are priced at $8 each, or in heavy paper cover at $7.

## Theory of the Properties of Metals and Alloys

**By N. F. Mott and H. Jones**

The authors discuss the present state of the electron theory of metals and its success in accounting for the observed properties of metals and alloys. By this means it is now possible to make quantitative calculations of the metallic bond in metals, predictions of crystal structure, and the phase equilibrium diagrams of alloys. The text also covers specific heats and thermal expansion of solids, the optical properties and color of metals and alloys, their magnetic properties and electrical conductivity. The treatment is essentially technical, and mathematical analysis is employed freely.

There are 326 pages, 6 × 9 1/4 in., cloth bound. Price $8.

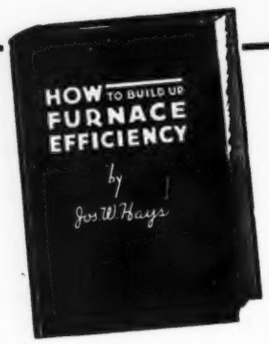
## Slagging Action of Western Pennsylvania Coals

**By C. R. Fettke and W. E. Stewart**

This presents the results of investigations undertaken by the authors, under the auspices of Carnegie Institute of Technology and the Mining and Metallurgical Advisory Boards to determine the slagging action of Western Pennsylvania coals on different types of refractories in a small pulverized coal installation. It was found that erosion of the refractories by coal is dependent on the ash composition and is related to the ash softening temperature in that no erosion occurs until the temperature of the refractory face exceeds the ash softening temperature. The higher this temperature the lower the erosion. Furthermore, the slag attack increases in direct proportion to increase in temperature after the critical temperature for a given refractory and ash has been passed.

This bulletin contains 90 pages and is priced at $1.

# PLACE THIS BOOK in the hands of YOUR STAFF!




**"HOW TO BUILD UP FURNACE EFFICIENCY"**

*by Jos. W. Hays*

★ *"It is as fine a book as I have ever seen and the publication of it does great credit."*

*Joseph Harrington*

★ *"This Book will be made good use of. It is printed in an easy, understandable fashion."*

*A Chief Engineer*

★ **584 Pages**
**250 Illustrations**
**Cloth Bound**
**Handsomely Printed**

***Set of Ringelmann Smoke Charts free with each copy.***

## A POPULAR PRESENTATION

### of boiler and furnace operation in an understandable way

● The more your men know, the better results they will get from the apparatus you give them. This book presents the knowledge of a recognized expert and reflects a lifetime of practical experience in improving boiler and furnace efficiency.

● The many cartoons and other pictures, with which the text is illustrated, make it as interesting to read as it is easy to understand.

● Every member of your operating staff can get from it a clear understanding of the working principles of instruments and equipment in your boiler plant and will thus become a better operator.

**PRICE $3.00 a copy. Quantity Discounts — 5 to 10 copies, 10%; 11 to 20 copies, 15%; 21 or more copies, 20%.**

**Combustion Publishing Company, Inc.**
**200 Madison Ave., New York, N. Y.**

Please send send me:—

☐ copy on approval.

☐ ——— copies @$3.00 each, subject to discounts listed above

☐ money enclosed. ☐ bill me.

NAME.....

ADDRESS.....


# EQUIPMENT SALES

## Boiler, Stoker, Pulverized Fuel

**as reported by equipment manufacturers of the Department of Commerce, Bureau of the Census**

### Boiler Sales

Orders for 273 water-tube and h.r.t. power boilers were placed in December

| | Number | Square Feet |
|---|---|---|
| December, 1936 | 273 | 1,569,887 |
| December, 1935 | 111 | 339,372 |
| January to December (inclusive, 1936) | 1,996 | 7,066,917 |
| Same period, 1935 | 1,161 | 3,507,850 |

NEW ORDERS, BY KIND, PLACED IN DECEMBER 1935–1936

| | December 1936 | | December 1935 | |
|---|---|---|---|---|
| Kind | Number | Square Feet | Number | Square Feet |
| Stationary: | | | | |
| Water tube | 197 | 1,487,696 | 57 | 265,701 |
| Horizontal return tubular | 50 | 55,960 | 35 | 54,064 |

### Mechanical Stoker Sales

Orders for 309 stokers Class 4* totaling 79,226 hp were reported in December by 41 manufacturers

| | Installed under | | | |
|---|---|---|---|---|
| | Fire-tube Boilers | | Water-tube Boilers | |
| | No. | Horsepower | No. | Horsepower |
| December, 1936 | 245 | 43,227 | 64 | 35,999 |
| December, 1935 | 159 | 18,379 | 37 | 15,787 |
| January to December (inclusive, 1936) | 2,724 | 386,868 | 649 | 276,687 |
| Same period, 1935 | 1,754 | 225,927 | 556 | 209,027 |

* Capacity over 300 lb of coal per hr.

### Pulverized Fuel Equipment Sales

Orders for 27 pulverizers with a total capacity of 316,400 lb per hr were placed in November†

**STORAGE SYSTEM**

| | Pulverizers | | | |
|---|---|---|---|---|
| | Total number | No. for new boilers | No. for existing boilers | Total capacity lb coal per hour for contract |
| November, 1936 | ... | ... | .. | ..... |
| November, 1935 | ... | ... | .. | ..... |
| January to November (inc., 1936) | ... | ... | .. | ..... |
| Same period, 1935 | ... | ... | .. | ..... |

**DIRECT FIRED OR UNIT SYSTEM**

| | Pulverizers, Water-tube Boilers | | | |
|---|---|---|---|---|
| November, 1936 | 27 | 24 | 3 | 316,400 |
| November, 1935 | 13 | 11 | 2 | 124,650 |
| January to November (inc., 1936) | 250 | 192 | 58 | 2,568,500 lb coal per hr |
| Same period, 1935 | 123 | 86 | 37 | 798,440 lb coal per hr |
| | **Fire-tube Boilers** | | | |
| November, 1936 | 2 | ... | 2 | 1,200 |
| November, 1935 | 2 | 1 | 1 | 1,385 |
| January to November (inc., 1936) | 22 | 4 | 18 | 25,100 |
| Same period, 1935 | 7 | 1 | 6 | 6,685 |

† December figures not yet available.

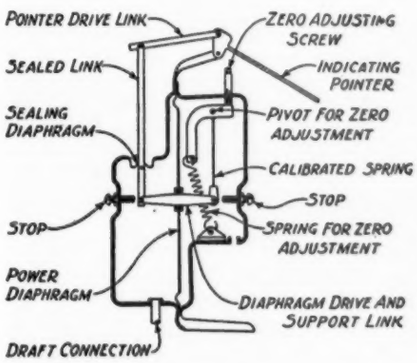
# NEW EQUIPMENT

## Multi-Pointer Gage

A new diaphragm-operated multi-pointer gage has been developed by the Bailey Meter Company for boiler room service. This consists essentially of a flat calibrated spring, a sealed link and a power diaphragm the weight of which is carried on a second link pivoted at one end on the calibrated spring and at the other end on the sealed link. Draft is applied on the left side of the diaphragm as shown, which causes movement of the system to the left. This movement is opposed by the spring. The motion is transmitted by the sealed link to the outside of the diaphragm unit where a drive link carries the motion to the indicating pointer.

For indication of pressure the connection is made on the opposite side of the diaphragm, and for indication of differential pressure the connections are made to both sides of the diaphragm. Of importance is the diaphragm material which is resistant to oil, acid, caustic and heat.

Each diaphragm unit is provided with a zero adjusting screw which may be

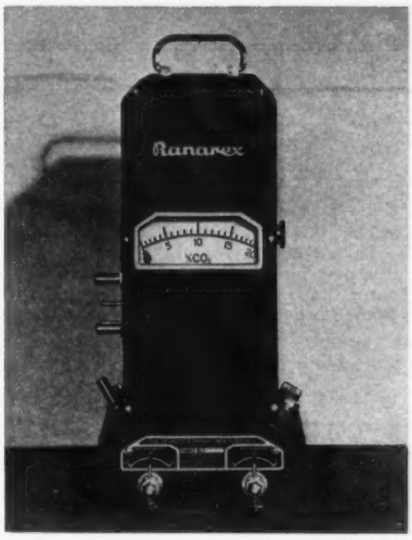



turned from outside the gage casing by means of an adjusting key.

The units are available in casings containing from one to twelve units and may be surface, semi-flush, or full flush mounted.

## Portable $CO_2$ Indicator

The Permutit Company has brought out a portable "Ranarex" $CO_2$ indicator which determines the $CO_2$ percentage continuously by the well-known mechanical principle, that the specific weight of flue gases varies with changes in the $CO_2$ content. In order to obtain a substantial force as a means of measuring the specific weight of the flue gas, a rotating motion is imparted to the gas by means of a motor-driven fan revolving in a chamber. This fan blows the gas against the blades of an impulse wheel, thus producing a torque on the shaft of the impulse wheel in proportion to the $CO_2$ content. Changes in fan speed, temperature, humidity and atmos-




pheric pressure are automatically compensated for by a comparing torque produced on another impulse wheel by air to which a rotating motion is imparted in a second chamber by a second fan driven by the same motor. The two impulse-wheel shafts are coupled together by means of a balancing linkage actuating the indicator, the scale being calibrated in terms of per cent $CO_2$.

## Gage Valves for High Pressures

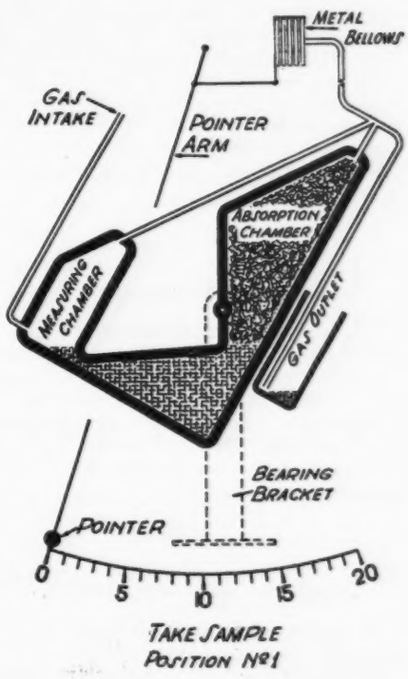
The Edward Valve & Mfg. Co., Inc., has redesigned its line of forged-body gage valves. Features include new type of tight-grip, unbreakable malleable hand wheels of oversize dimensions and extra long taper-threaded bonnet joints. Back-seating shoulders prevent hardened stainless stems from backing out and allow repacking under pressure. Drop forged bodies preclude danger from seams and porosity and permit overstressing with safety. Working pressure ratings are from 4000 lb at 150 F and 600 lb at 750 F to 475 lb at 1000 F. These valves are available in sizes $^1/_8$ in. to 1 in. in carbon and alloy steels.

## Remote-Reading Water Gage

Convenient and exact reading of boiler water gages is made possible through the "EYE-HYE," a new remote-reading gage of the Reliance Gauge Column Company. This brings the reading down to a clear, convenient eye height, showing the precise level of the water in the boiler as a bright green liquid, sharply illuminated. It also brings the reading down around corners, girders, piping, anywhere within reasonable distance.

## Automatic Orsat

A sample of flue gas can be analyzed in 20 sec by simply operating a lever, on the new automatic orsat recently brought out by The Hays Corporation, and the results are indicated by a pointer on the scale.




No special training is required to analyze a sample of flue gas. The operator simply aspirates the sample into the instrument while it is in the sampling position (rod up). The automatic valve allows the gas to bypass so that it is always measured at atmospheric pressure. The rod is then pushed down to the analyzing position, sealing the automatic valve, rotating the analyzing body and causing the mercury to flow to a new position. The liquid absorbing chemical floats on top of the mercury and the gas sample is displaced from the measuring chamber into the absorption chamber where it is forced into contact with steel wool saturated with the absorbing chemical. The absorption of the $CO_2$ causes a shrinkage in volume of the sample and creates a partial vacuum which is transmitted to the pointer by a metallic bellows.

# NEW CATALOGS AND BULLETINS

**Any of the publications will be sent on request.**

### Centrifugal Pumps

Centrifugal pumps for boiler feed service up to 1000 lb per sq in. are dealt with in a recent bulletin issued by the Worthington Pump and Machinery Corporation. Specifications are included as to dimensions, capacities, heads and speeds.

### Corrosion Prevention

Publication No. 2540, just issued by the Cochrane Corporation, Philadelphia, is devoted to a discussion of the prevention of corrosion by complete removal of oxygen and dissolved gases from the feedwater—a condition that is imperative under present operating conditions. Cochrane deaerators are described in detail and fully illustrated.

### Leather Products

Leather belting in a variety of types, packing and valve leathers are dealt with in an attractively illustrated catalog lately issued by Alexander Brothers, Inc., Philadelphia. Useful tables are included for calculating belt speed, pulley diameters, horsepower transmitted, etc., and price lists are given.

### Mechanical Flow Meters

Cochrane Corporation of Philadelphia, has issued a 16-page bulletin, No. 2094, describing in detail the operating principles and features of its line of mechanical flow meters. These are made in the indicating, recording, integrating, or combination types.

### New Insulating Brick

Johns-Manville has recently placed on the market a new type of 2000 F-insulating brick known as "JM-20."

This new brick was developed for use behind refractory walls in various types of high temperature industrial equipment, including boiler settings, ceramic kilns, steel plant equipment and practically all types of furnaces. It can also be used for direct exposure at temperatures up to 2000 F wherever there is no flame impingement, slag action or mechanical abrasion. This brick is light in weight, weighing less than 1.7 lb per standard 9-in. equivalent, and its thermal conductivity is less than one-sixth that of firebrick.

Data sheets giving full particulars on this new insulating brick have been prepared and may be obtained from the Johns-Manville Company upon request.

### Oil Testing Instruments

Catalog No. 699D recently issued by C. J. Tagliabue Mfg. Co., Brooklyn, N. Y., describes that company's line of art testing instruments, including thermometers, hydrometers, colorimeters, chronometers, viscosimeters, cloud and pour-test apparatus as well as many special testing instruments employed in the production of petroleum products. Price lists are included.

### Pulverizers

The Whiting Corporation, Harvey, Ill., has issued Bulletin No. 15, containing 48 pages devoted to its line of impact and roller mills for fine grinding, its pneumatic conveying system, pulverized coal burners and auxiliary equipment. Sections are also included on pulverizing in the process industries. The bulletin is well illustrated and contains some performance data.

### Pumps and Pumping Machinery

"Engineering Data and Prices" is the title of a 233-page book just issued by the Economy Pumping Machinery Company, Chicago. This covers centrifugal pumps of the double-suction, single-stage horizontal type; small vertical multi-stage pumps; horizontal, split-case multi-stage pumps; single-suction, single-stage vertical pumps; close-coupled, single-stage types; sump pumps and ejectors; axial flow pumps; return-line vacuum heating pumps; condensation pumps of both the centrifugal and reciprocating types; and pump accessories. Specification data and prices are given for each type. In addition much useful engineering data are included on friction in pipes; pump materials for handling various fluids; and the determination of pump capacities for various services.

### Sicromo Steels

The Timken Steel & Tube Company, Canton, O., has just prepared a new 8-page folder presenting additional information on the Sicromo 1, 2, 3 & 5 steels recently announced. Analyses of these new steels are given and the effect of both silicon and chromium on the oxidation resistance of steels in which they are used is discussed.

### Silent-Chain Drive

A 96-page, 1936 edition of Data Book No. 125 on silent-chain drives from fractional horsepower up to 2000 hp, has been completed by Link-Belt Company, Chicago. The new data book reflects the progress of approximately five years since the preceding edition was published. The contents include installation pictures, engineering data, recommended drive selection, lubrication and casings, dimensions of chains and parts, list prices of chains and wheels, dimensions of wheel rims, hub sizes, bores, keys, chain adjustors, breaking pin hubs and electrical data.

### Thermometers and Pressure Gages

The Brown Instrument Company, Philadelphia, has recently issued a new 72-page catalog on thermometers and pressure gages of the indicating, recording and controlling types. It describes and illustrates the various instruments in this line, as well as the principles of operation, and lists the charts applicable to each.

### Turbine Pumps

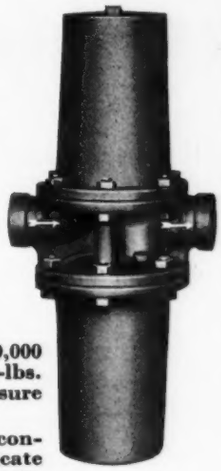
Roots-Connersville Blower Corp. of Connersville, Ind., has just issued Bulletin 260–B11B descriptive of its line of Type "T" turbine pumps, including numerous recent refinements in the design and construction. There is included a selection table, showing pumps for capacities from 5 to 200 gpm, at heads up to 300 ft. Ratings are based on standard motor speeds of 1750 or 3450 rpm. A performance curve is also included, along with a table giving specifications of the bronze-fitted, all-iron and all-bronze pumps of standard construction. This line of pumps includes those for boiler feed and condensate return as well as those for industrial applications.

### Water Analysis

Methods, chemicals and apparatus required for water analysis, together with instructions for their use are discussed in a 32-page booklet issued by W. H. & L. D. Betz, chemical consultants, of Philadelphia. This is the third edition of this booklet, revised to October 1936.

## Compound Steam Traps for

# Super-Capacity



- **Standard sizes for loads up to 240,000 lbs. per hr. continuous flow at 600-lbs. maximum pressure. Higher pressure or larger capacity built on order.**
- **Simple, compact, fool-proof construction. No springs, floats, or delicate mechanism. Only three moving parts.**
- **All the advantages of genuine Armstrong Inverted Bucket Design: Quick opening and closing . . . no wire-drawing . . . non-air-binding . . . self-scrubbing.**
- **Ideal for draining large steam purifiers, separators, flash tanks, continuous blow-down systems, de-superheaters, evaporators, etc.**

***Write for specification sheets.***

**ARMSTRONG MACHINE WORKS**
*814 Maple Street* *Three Rivers, Mich.*


## $200,000 to Be Awarded for Arc Welding Papers

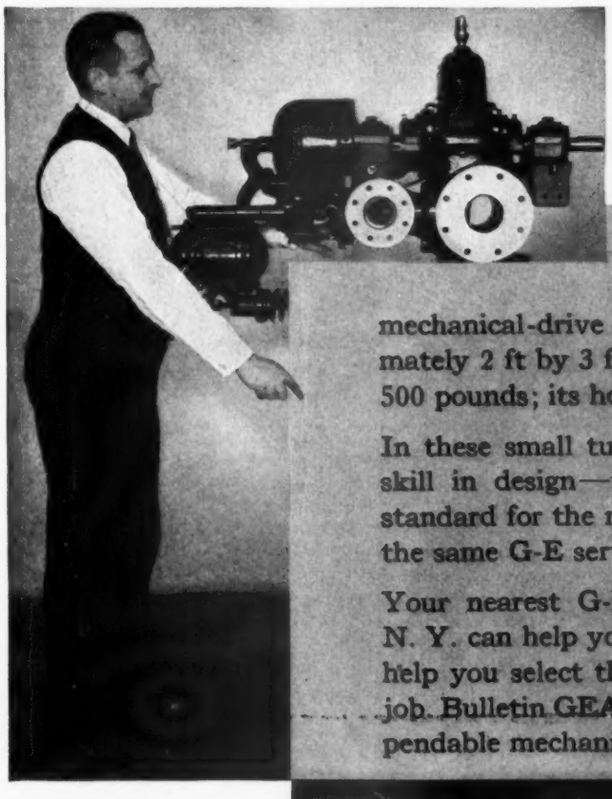
One of the richest awards ever established for competition in the field of mechanical science has been announced by The James F. Lincoln Arc Welding Foundation.

To stimulate intensive study of arc welding, $200,000 will be distributed by the Foundation among winners of 446 separate prizes for papers dealing with this subject as a primary process of manufacture, fabrication or construction in eleven major divisions of industry.

The principal prize winner will receive not less than $13,700. Other prizes range from $7500 to $100, the latter sum to be awarded each of 178 contestants who receive no other prize, but whose papers are adjudged worthy of honorable mention.

In order to assure equal competitive opportunity, similar prizes are offered in the eleven major divisions of industry covered by the contest. These divisions are: automotive, aircraft, railroad, watercraft, structural, furniture and fixtures, commercial welding, containers, welderies, functional machinery and industrial machinery. In the last-mentioned division fifty-four prizes, totalling $25,300 have been allotted.

To participate in this contest, it is necessary that submitted papers describe either the redesign of an existing machine, structure, building, etc., so that arc welding may be applied to its manufacture; or that they present a design (either in whole or in part) of a machine, structure, building, etc., not previously made, the description to show how a useful result, which was impractical with other methods of construction or could better be done by arc welding, is obtained.

**FOR SMALL TURBINES, TOO, SEE GENERAL ELECTRIC**

THE picture shows, in true proportion, our Type D-57 mechanical-drive turbine, which occupies a space approximately 2 ft by 3 ft by less than 2 ft high. Its weight is about 500 pounds; its horsepower ranges from 5 to 125.

In these small turbines is the same engineering—the same skill in design—that makes large G-E turbines practically standard for the nation's great power plants. Back of them is the same G-E service.

Your nearest G-E office or General Electric, Schenectady, N. Y. can help you in planning any turbine installation—can help you select the most economical unit for your particular job. Bulletin GEA-1145C will show you our complete line of dependable mechanical-drive turbines. Why not send for it now?

720-270

**GENERAL ELECTRIC**

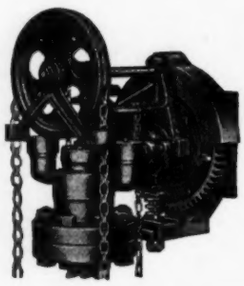
# ADVERTISERS


American Blower Corporation..... 42
Appalachian Coals, Inc..... 18
Armstrong Machine Works..... 51
C. O. Bartlett & Snow Company, The. .....Fourth Cover
Bayer Company, The..... 52
Buromin Company, The..... 17
Cochrane Corporation ..... 2
Combustion Engineering Company, Inc.....Second Cover, 14 and 15
De Laval Steam Turbine Company.... 41
Edward Valve & Mfg. Company, Inc., The ..... 13
Ernst Water Column & Gage Company 52
General Coal Company..... 16
General Electric Company..... 51
Hagan Corporation..... 17
Hall Laboratories, Inc..... 17
Hays Corporation, The..... 6
Ingersoll-Rand Company.....Third Cover
Johns-Manville ..... 7
Johnston & Jennings Company, The.. 8
Jones & Laughlin Steel Corporation... 19
National Aluminate Corporation..... 20
Permutit Company, The..... 9
Plibrico Jointless Firebrick Company. 46
Poole Foundry & Machine Company.. 45
Prat-Daniel Corporation..... 3
Refractory & Insulation Corporation.. 44
Reliance Gauge Column Company.... 44
Republic Flow Meters Company..... 12
Cyrus Wm. Rice & Company, Inc..... .....10 and 11
Yarnall-Waring Company.....4 and 5



## CHRONILLOY ELEMENTS

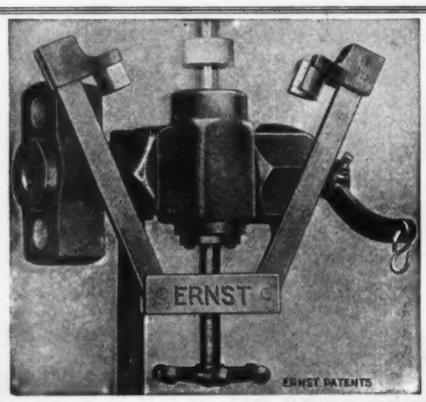
HOW MUCH IS IT COSTING you to maintain the SOOT CLEANER ELEMENTS in the HIGH TEMPERATURE positions of your boilers? Here is an element sold with an 18 MONTHS SPECIAL UNQUALIFIED SERVICE GUARANTEE. COST MORE? Yes, but WHAT SERVICE LIFE!



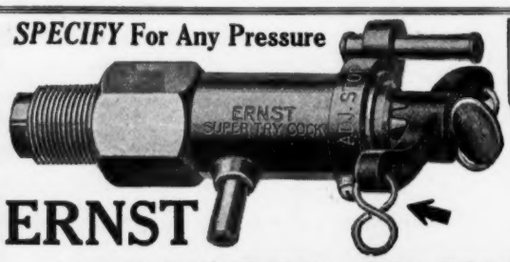
## BALANCED VALVE-IN-HEAD

FIRST QUALITY IN DESIGN, WORKMANSHIP AND MATERIAL. Back of this IMPROVED SOOT CLEANER HEAD lies years of study to make it trouble free and give dependable service day after day. Analyze before you buy as cheap imitations may be offered.

**THE BAYER COMPANY**
4067 Park Ave. St. Louis, U. S. A.




*SPECIFY* For Any Pressure




ERNST
**LEAKLESS COCKS**
**"SPLIT-GLAND" WATER GAGES**
MADE TO FIT ANY COLUMN OR BOILER

CAN BE ATTACHED TO ANY WATER COLUMN OR BOILER
ALIGNMENT AND STIFFENER ROD
NO GAGE GLASS PACKING NUTS
GLASS CAN BE SET AT ANY ANGLE OR VERTICAL

*Write for Catalog C* ERNST WATER COLUMN & GAGE CO., NEWARK, N. J. *Offices in Principal Cities*